

Results from COHERENT

Jason Newby
for the COHERENT collaboration

XIXX International Conference on Neutrino Physics and Astrophysics
June 23, 2020
Fermilab/Virtual

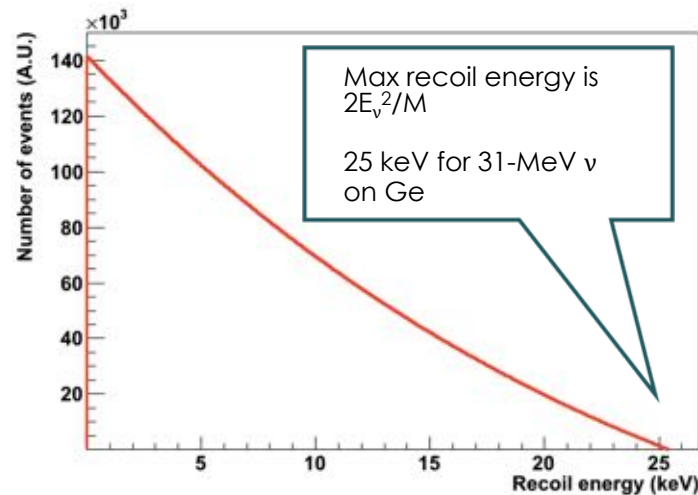
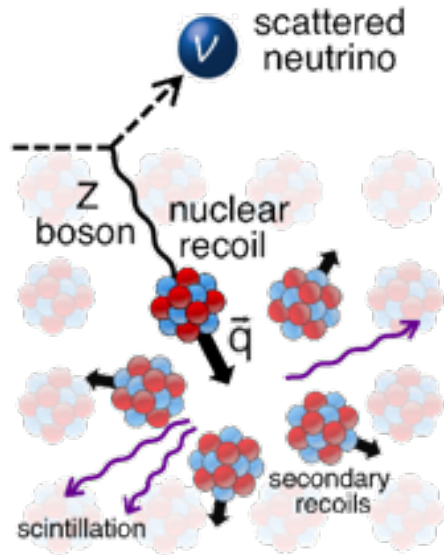
ORNL is managed by UT-Battelle, LLC for the US Department of Energy



U.S. DEPARTMENT OF
ENERGY

Coherent elastic neutrino-nucleus scattering (CEvNS)

A neutrino scatters on a nucleus via exchange of a Z , and the nucleus recoils as a whole; **coherent** up to $E_\nu \sim 50$ MeV



CEvNS cross section is well calculable in the Standard Model

$$\frac{d\sigma}{d\Omega} = \frac{G^2}{4\pi^2} k^2 (1 + \cos \theta) \frac{(N - (1 - 4 \sin^2 \theta_W)Z)^2}{4} F^2(Q^2)$$

CEvNS cross section is large!

$$\propto N^2$$

- Predicted in 1974 by D. Freedman
- Interesting test of the standard model
 - Sensitive to **non-standard interactions**
 - Largest cross section in **supernovae** dynamics
 - Background for future **dark matter** experiments
 - Sensitive to nuclear physics, **neutron skin** (neutron star radius)
- “act of hubris” - D. Freedman
 - Need a low threshold detector
 - Need an intense neutrino source

The COHERENT Collaboration



December 2019 @ UTK

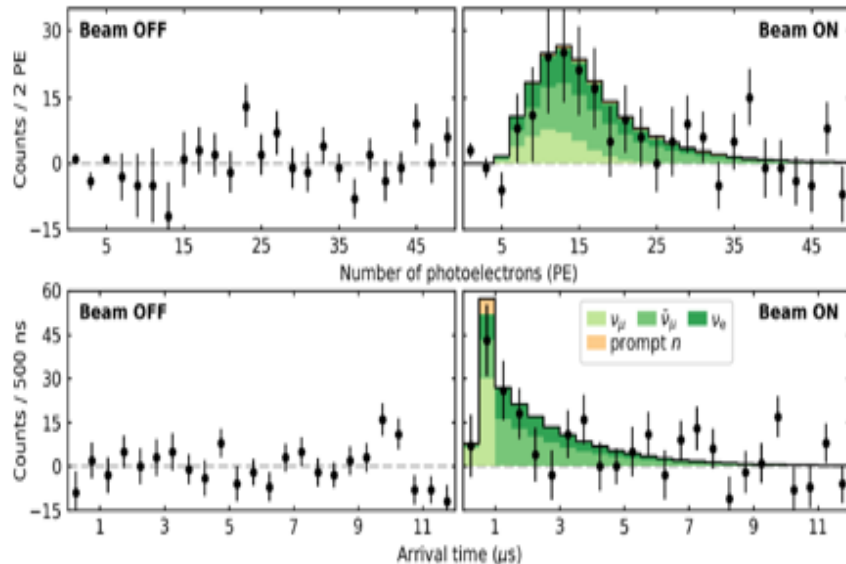
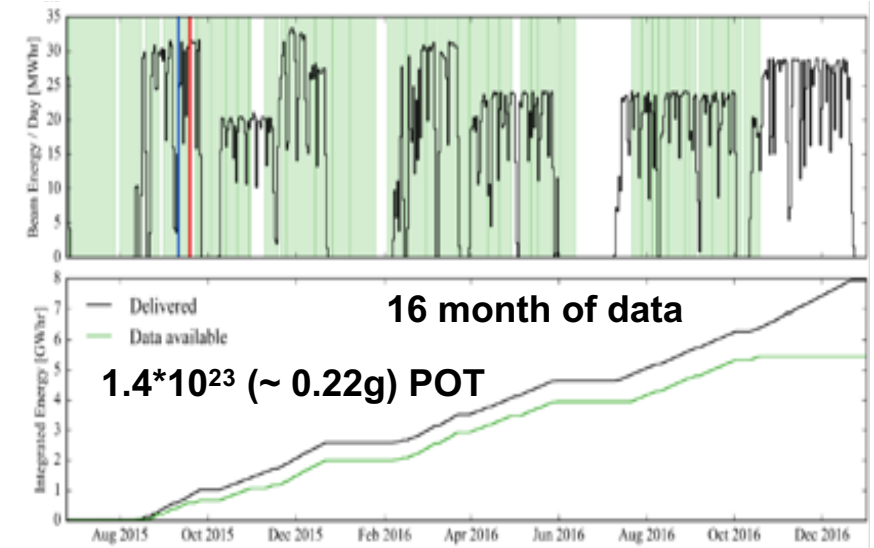
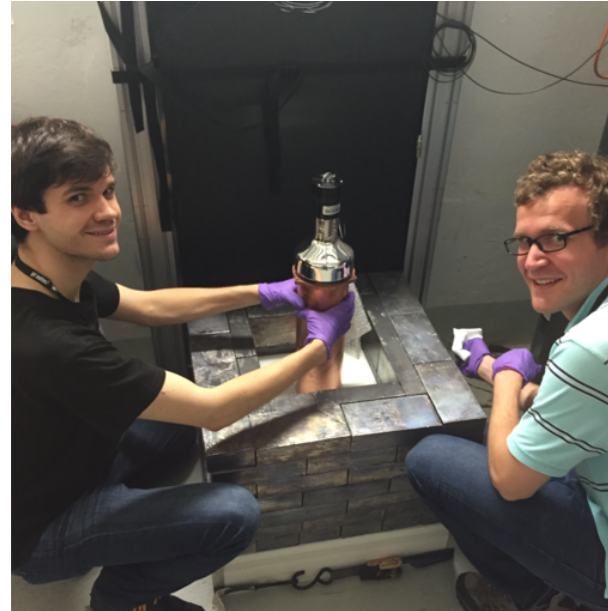
21 Institutions (USA, Russia, Canada, Korea)

Goal: First Experimental Observations of CEvNS on multiple nuclei at a stopped-pion neutrino source.



[arXiv:1803.09183v2](https://arxiv.org/abs/1803.09183v2)

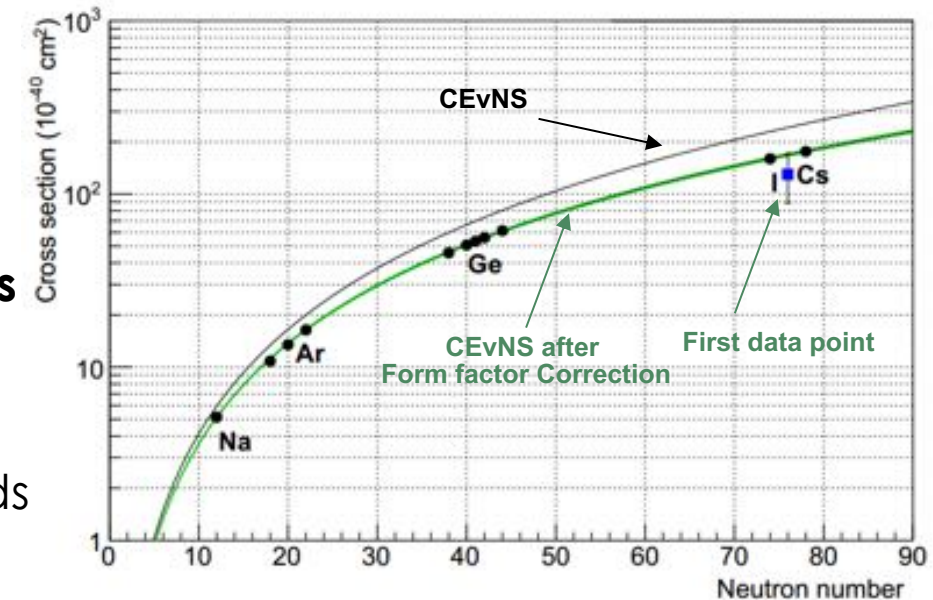
First Detection of CEvNS with CsI detector



First working, hand held
neutrino detector -14kg!!!

After 40 years, all the pieces
have finally come together

- ✓ Intense Neutrino Source
- ✓ Sensitive Detectors
- ✓ Mitigation of Backgrounds



Neutrino 2020 Virtual Meeting

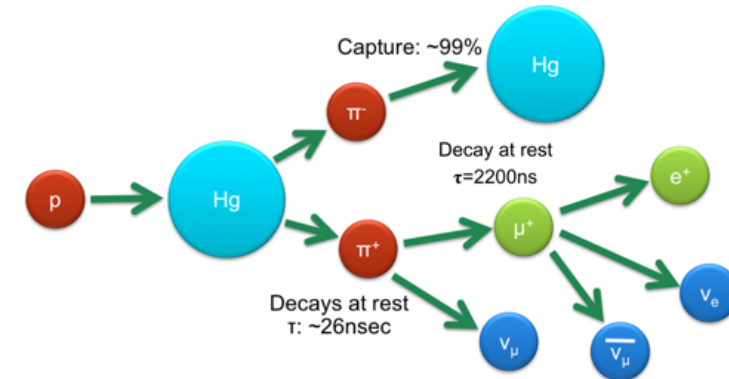
J. Newby

Spallation Neutron Source at ORNL



- Superconducting H⁻ LINAC: 1 GeV @ 1.4MW @ 60 Hz
- Storage Ring: 1200 pulses, 1us Period, 350ns FWHM
- Liquid Mercury Target: circulates 20 tons with He gas injection to mitigate cavitation
- Operation ~5000 hours per year: 25 Terajoules/year

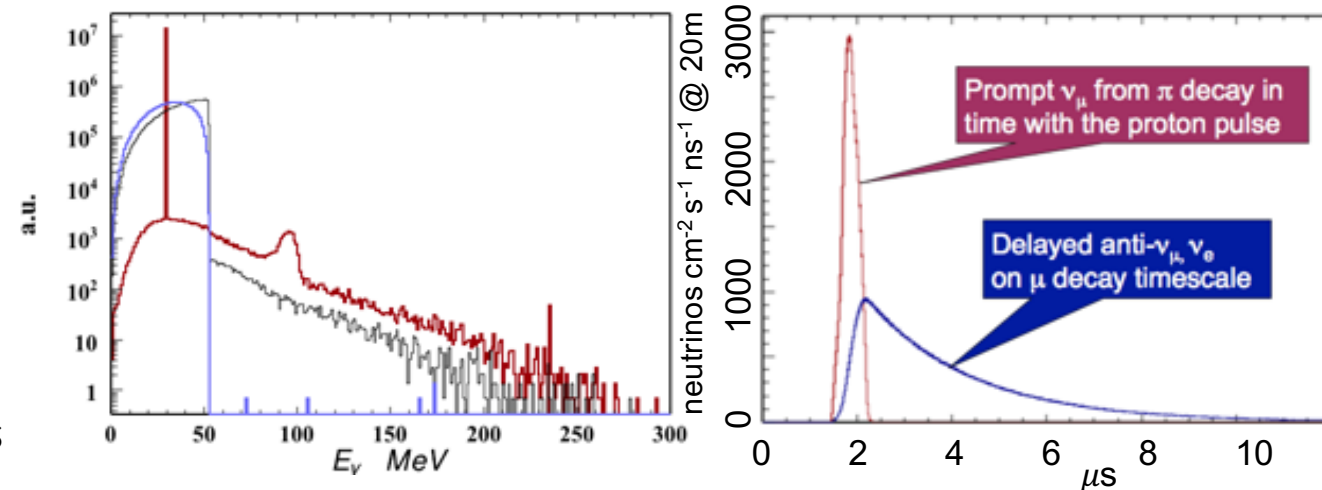
Neutrinos via Pion Decay-at-Rest



$2.81 \times 10^{14} \nu/\text{cm}^2/\text{flavor}/\text{SNSYear} @ 20\text{m}$

Neutrino Energy

Neutrino Timing



- SNS timing preserves DAR flavor structure
- Mono-energetic ν_μ separated from $\nu_e, \bar{\nu}_\mu$

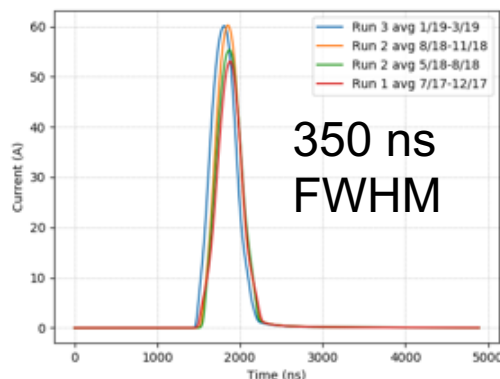
What were the required elements?

Low Noise Detectors and Low Background Materials
from DM and $0\nu\beta\beta$ Detector R&D

Neutrino Alley is well-shielded from beam related backgrounds

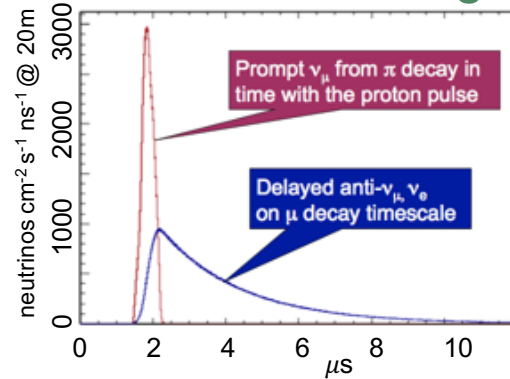
Pulsed Timing Structure of Neutrinos

Measured Proton Pulse

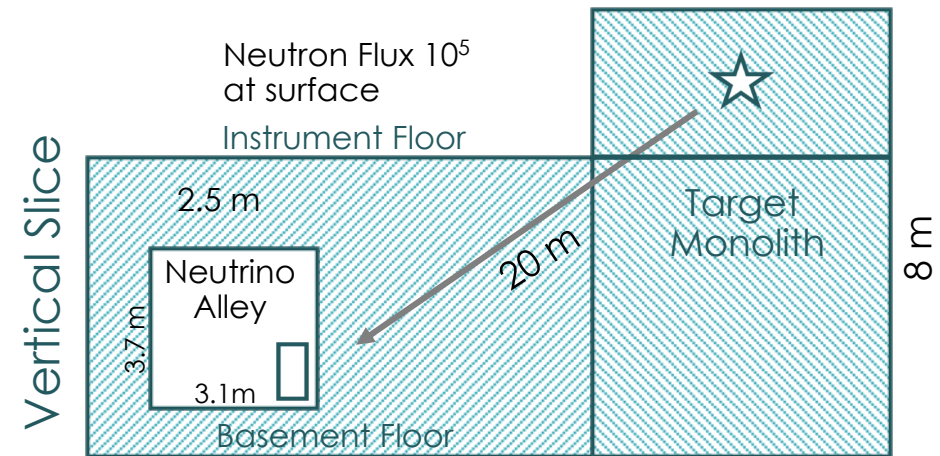


Lara Blokland, UTK

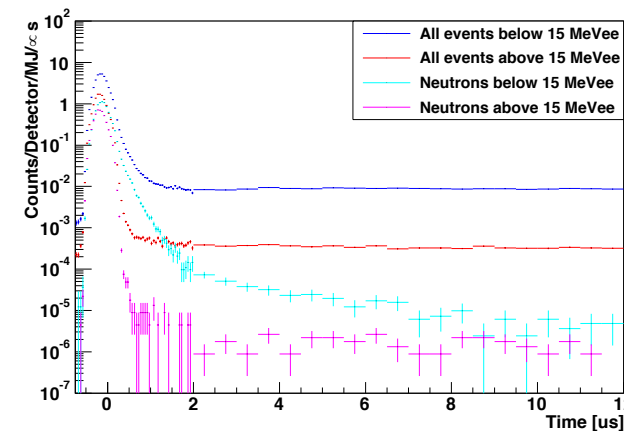
Neutrino Flavor Timing



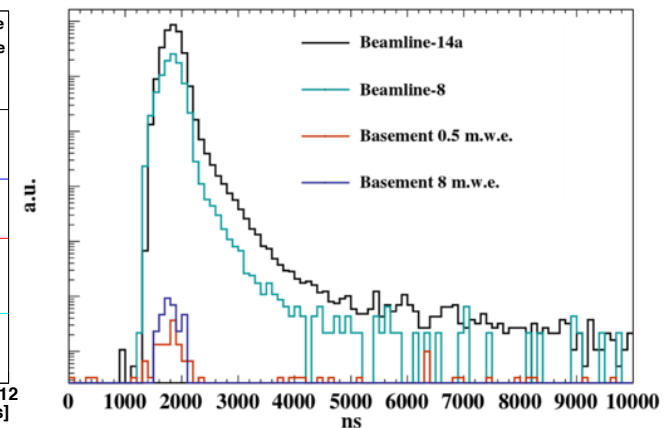
- Constrains systematics on beam-related backgrounds.
- Enables flavor dependent analyses
- Enables prompt searches for exotic particles



SNS Instrument Floor



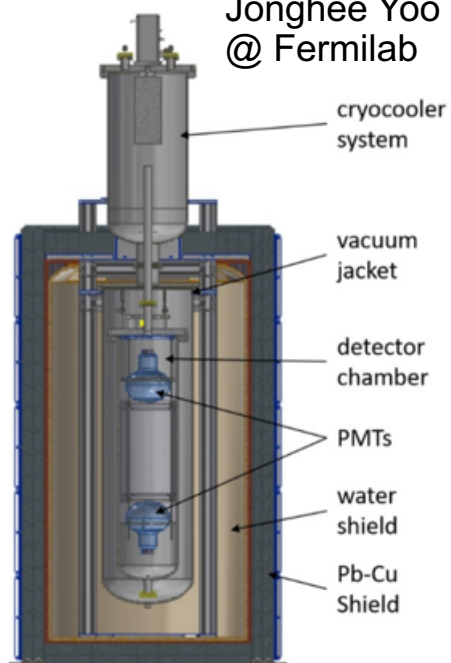
Basement Shielding



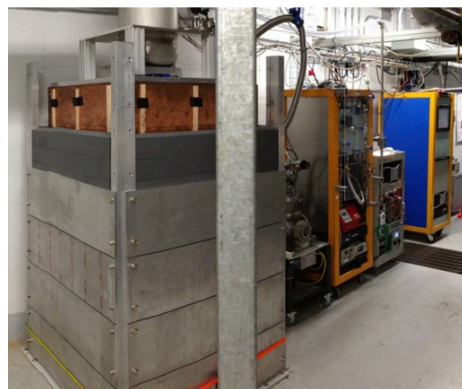
COHERENT CEvNS on Argon

CENNS-10 Liquid Argon Detector

Jonghee Yoo
@ Fermilab



- 24 kg Fiducial Mass
- Single Phase
- $\text{Kr}^{83\text{m}}$ Calibration Source
- 4.5 p.e. per keVee
- ~20 keVnr threshold
- 6.12 GWhrs



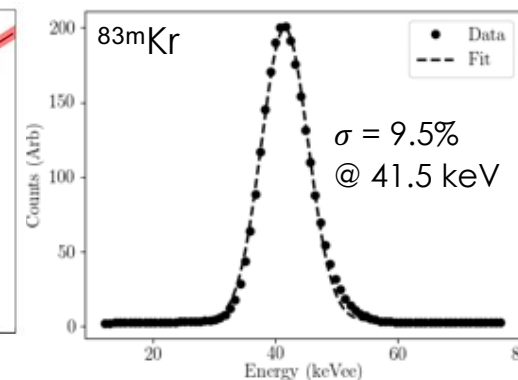
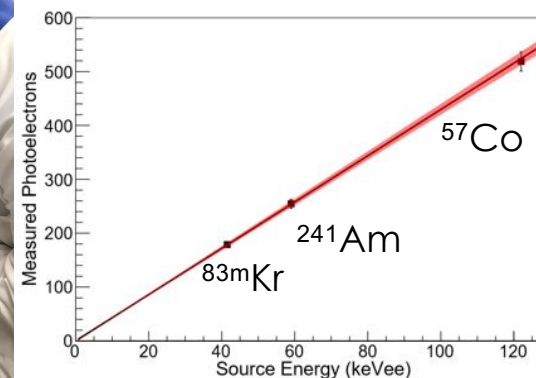
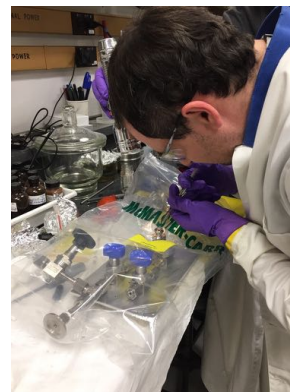
Installed @ SNS
November 2016

D. Akimov *et al.* Phys. Rev. D **100**, 11

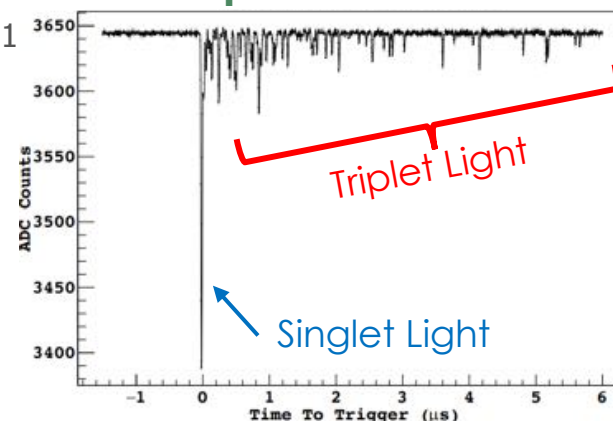


Light Collection
Upgrade June 2017

Energy Calibrations: ^{241}Am , ^{57}Co , $^{83\text{m}}\text{Kr}$ Sources

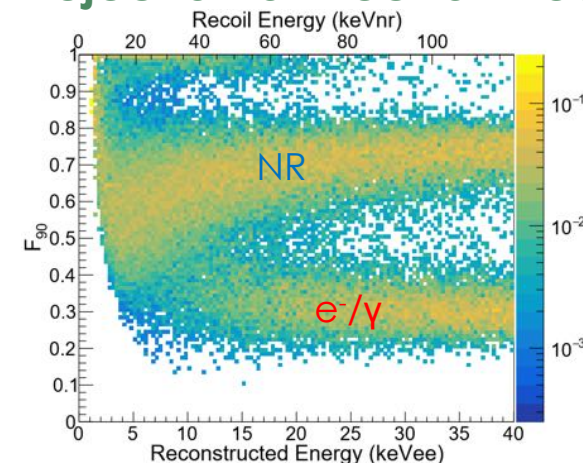


Example Waveform



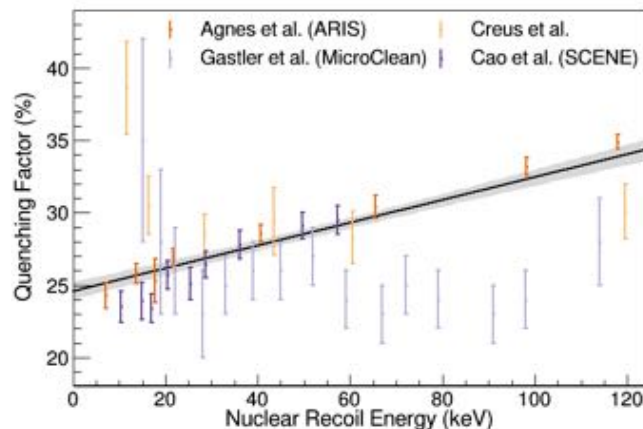
M. Heath (IU) dissertation completed 2019
D. Akimov *et al.* Phys. Rev. D **100**, 115020
J. Zettlemoyer (IU) dissertation 2020
arXiv:2003.10630

Rejection of Electron Recoils

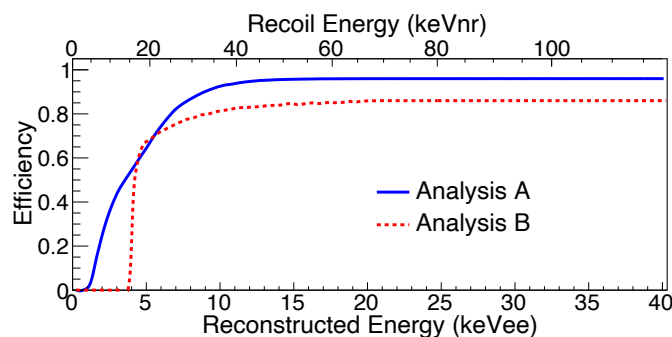


First CEvNS Observation on Argon

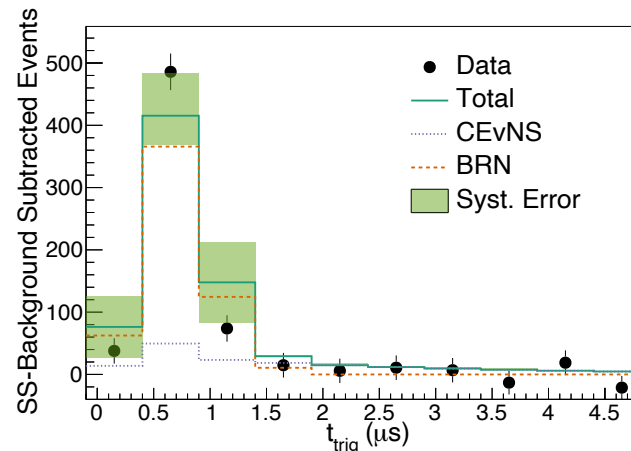
Global Fit to Argon Quenching Factor Data



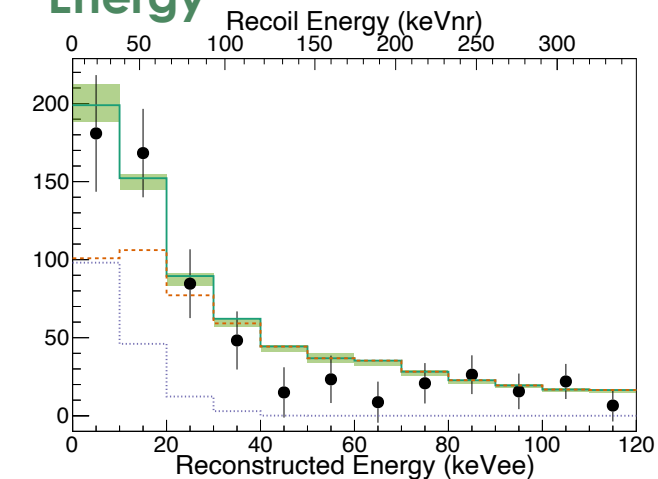
Two Independent Blind Analyses



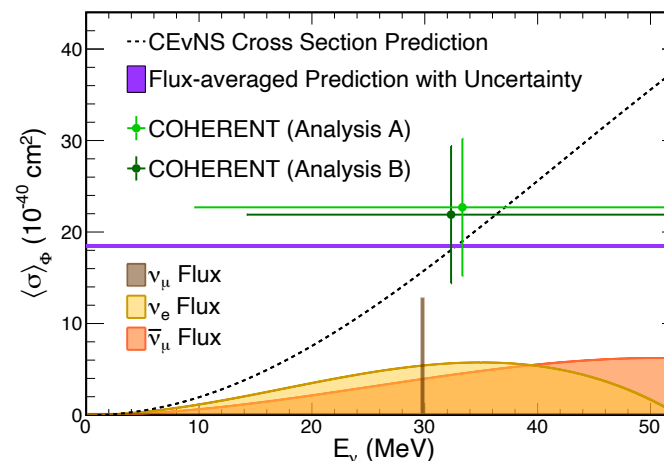
Time



Energy



CEvNS Cross section



Combine best fits CEvNS counts with flux, fid. Volume, efficiency uncertainties,

$$\frac{N_{\text{meas}}}{N_{\text{SM}}} = 1.2 \pm 0.4$$

Obtain flux-averaged cross section:

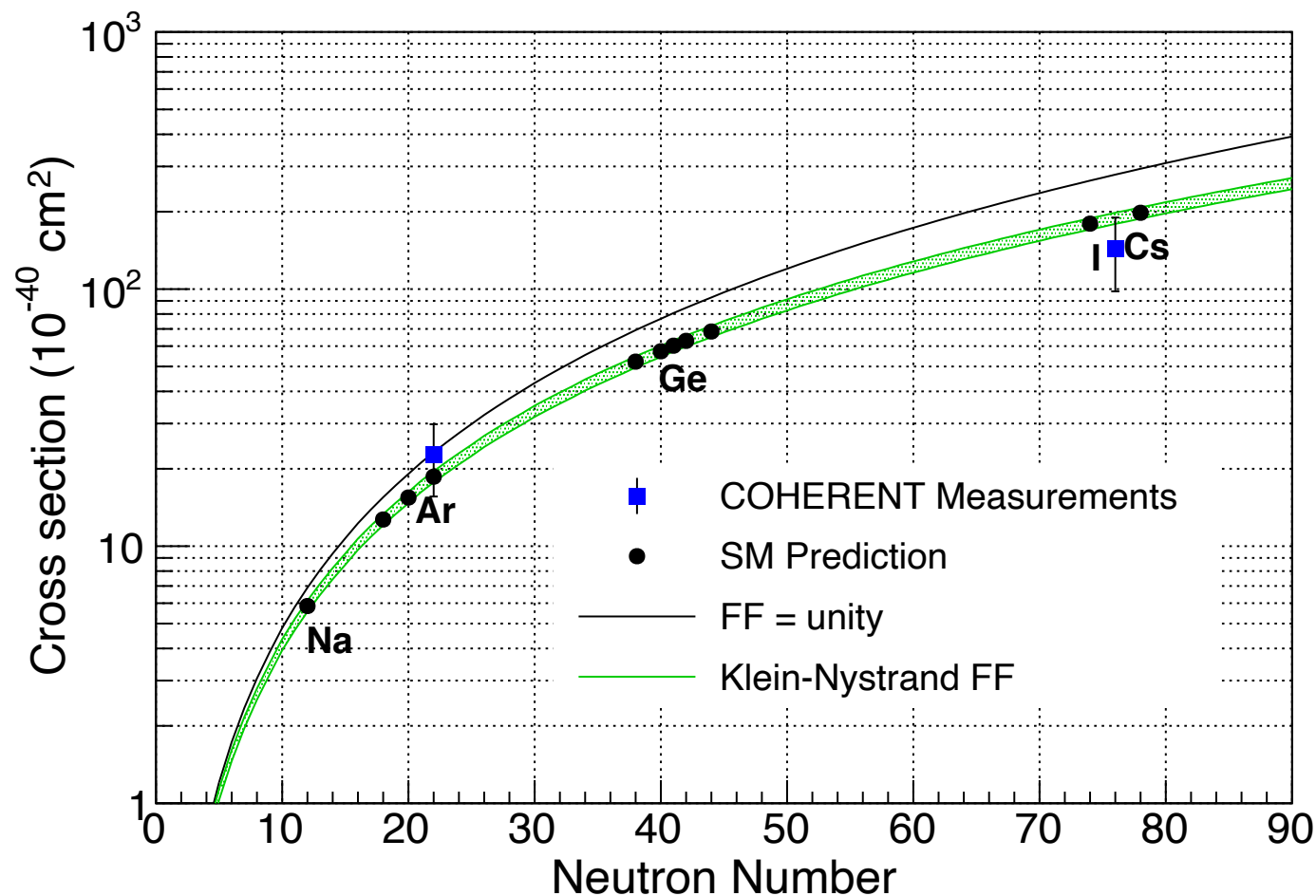
$$\sigma_{\text{meas}} = (2.3 \pm 0.7) \times 10^{-39} \text{ cm}^2$$

Statistics dominated

J. Zettlemoyer (IU) dissertation 2020
arXiv:2003.10630

See Poster #49
Jacob Zettlemoyer

First Confirmation of SM Prediction of N^2 Dependence



More to come ...

CsI

- ✓ Twice the statistics
- ✓ Live-time correction
- ✓ New QF Measurement
- ✓ Verified Linearity of QF PMT *

LAr

- Twice the statistics in hand and $\sim 5\sigma$ by December 2020
- ✓ Improved Neutron Shielding
- ✓ Data release this week!

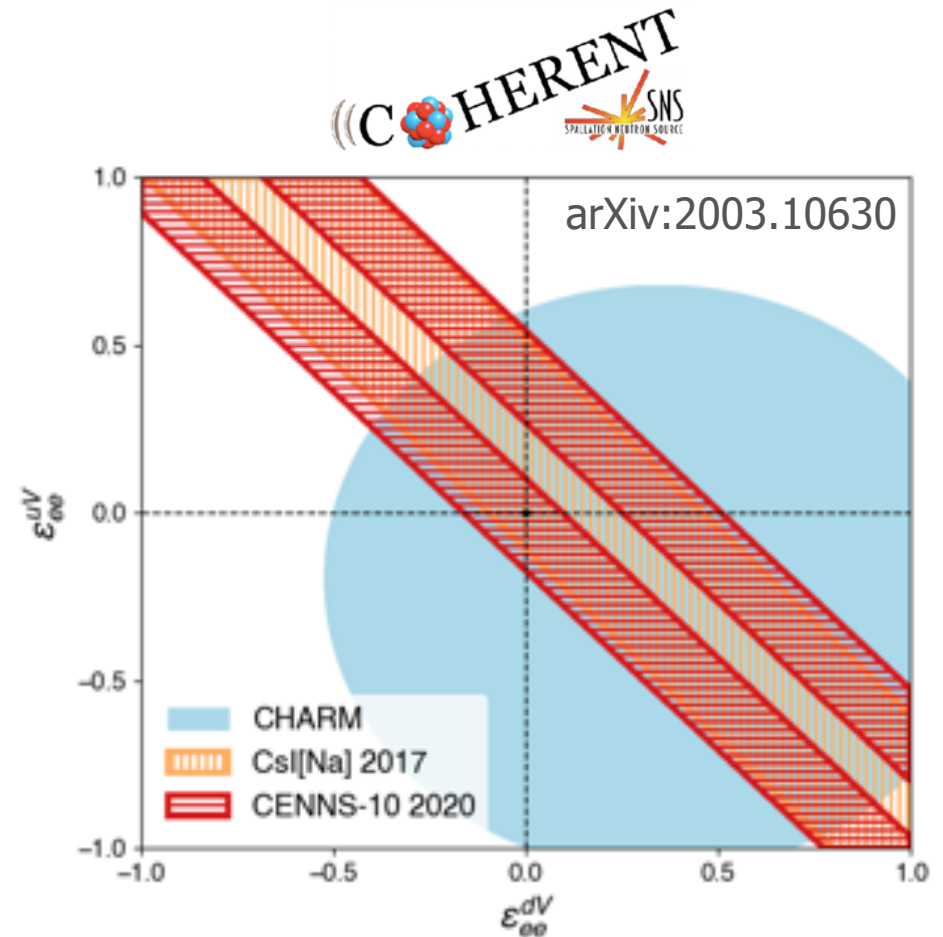
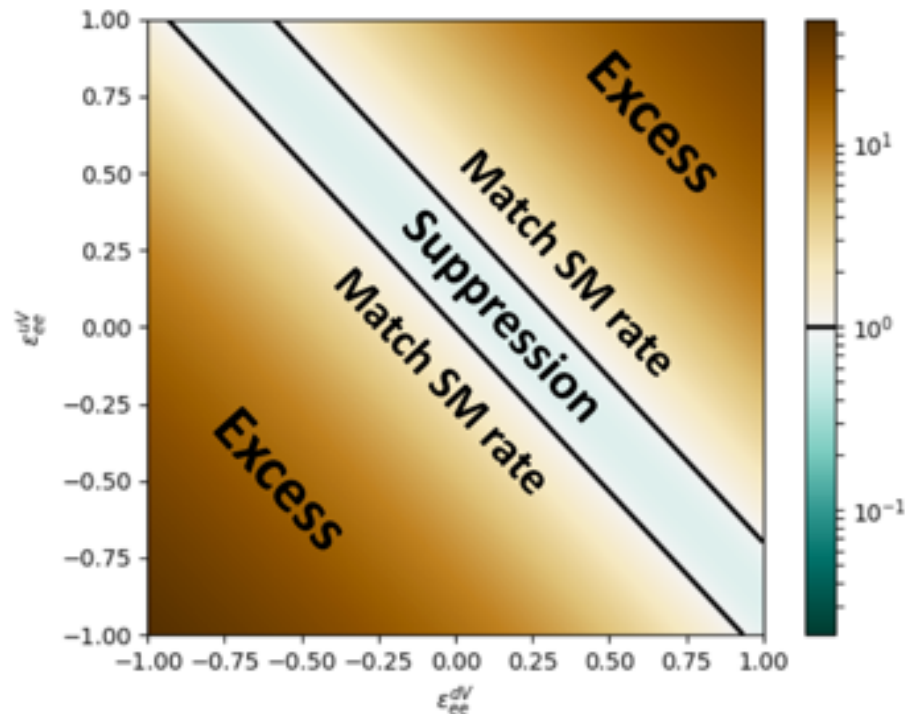
<https://doi.org/10.5281/zenodo.3903810>

* [Alexey Konovalov 2019 M7s Presentation](#)

New Constraints on Non-standard Interactions

Modified Cross Section

$$Q_W^2 \rightarrow Q_{\text{NSI}}^2 = 4 \left[N \left(-\frac{1}{2} + \epsilon_{ee}^{uV} + 2\epsilon_{ee}^{dV} \right) + Z \left(\frac{1}{2} - 2\sin^2 \theta_W + 2\epsilon_{ee}^{uV} + \epsilon_{ee}^{dV} \right) \right]^2 + 4 \left[N(\epsilon_{e\tau}^{uV} + 2\epsilon_{e\tau}^{dV}) + Z(2\epsilon_{e\tau}^{uV} + \epsilon_{e\tau}^{dV}) \right]^2.$$

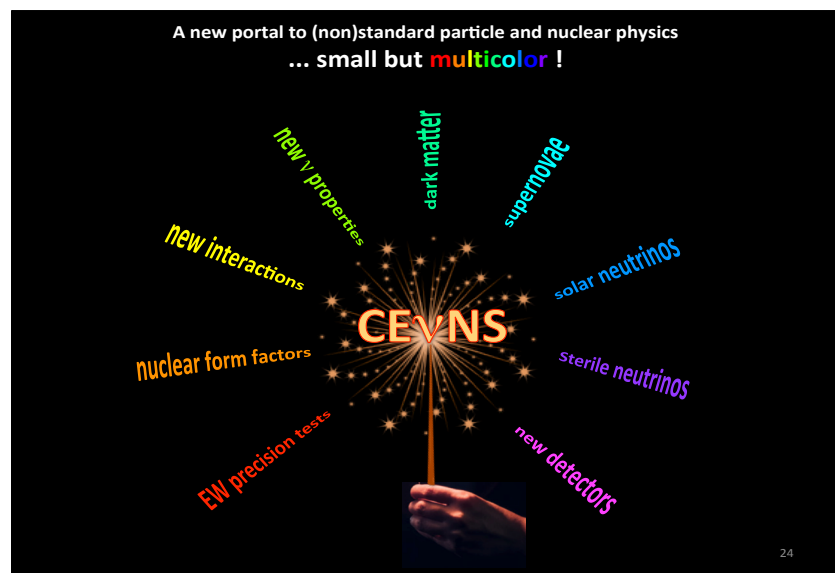


Latest COHERENT result significantly improves constraint on ν_e coupling with u,d quarks.

J. Barranco et al. Phys Rev D 76 (2007)

J. Billard, J. Johnston, B. Kavanagh. arXiv:1805.01798

CEvNS as Probe of New Physics



Slide by Eligio Lisi at NuInt 2018
<https://indico.cern.ch/event/703880/>

From “Can we see it?”
to “What can we do with it?”



COHERENT constraints on nonstandard neutrino interactions

Jiajun Liao^{a,*}, Danny Marfatia

PHYSICAL REVIEW D **96**, 115007 (2017)

COHERENT enlightenment of the neutrino dark side

Pilar Coloma,^{1,a} M. C. Gonzalez-Garcia,^{2,3,4,†} Michele Maltoni,^{5,‡} and Thomas Schwetz^{6,§}

The COHERENT experiment has demonstrated the scientific potential of a CEvNS program using the intensity, timing structure, and hermetic shielding at the Spallation Neutron Source.

Community Workshops

- nuEclipse 2017
- Magnificent CEvNS Workshops, 2018 Chicago, 2019 Chapel Hill
- Second Target Station Science Workshops, July 2019, Dec 2019

PHYSICAL REVIEW LETTERS **120**, 072501 (2018)

Average CsI Neutron Density Distribution from COHERENT Data

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Dipartimento di Fisica, Università degli Studi di Cagliari, and INFN, Sezione di Cagliari,
Complesso Universitario di Monserrato—S.P. per Sestu Km 0.700, 09042 Monserrato (Cagliari), Italy

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Testing large non-standard neutrino interactions with arbitrary mediator mass after COHERENT data



by M. Steinhauser

PHYSICAL REVIEW D **98**, 075018 (2018)

Constraints on nonstandard neutrino interactions from the COHERENT experiment

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COHERENT analysis of neutrino generalized interactions

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³AHEP Group, Instituto de Física Corpuscular, CSIC/Universitat de València,
Calle Catedrático José Beltrán, 2 E-46100 Burjassot, Spain

Reinterpreting the weak mixing angle from atomic parity violation in view of the Cs neutron rms radius measurement from COHERENT

M. Cadeddu^a and F. Dondeddu^b
INFN, Sezione di Cagliari, Complesso Universitario di Monserrato
- S.P. per Sestu Km 0.700, 09042 Monserrato (Cagliari), Italy

PHYSICAL REVIEW D **97**, 033003 (2018)

COHERENT constraints to conventional and exotic neutrino physics

D. K. Papoulias^a and T. S. Kosmas^b

Theoretical Physics Section, University of Ioannina, GR-45110 Ioannina, Greece

(Received 4 December 2017; published 15 February 2018)

Neutrino Charge Radii from COHERENT Elastic Neutrino-Nucleus Scattering

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Department of Nuclear Physics and Quantum Theory of Collisions,
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Y.F. Li[†] and Y.Y. Zhang[‡]

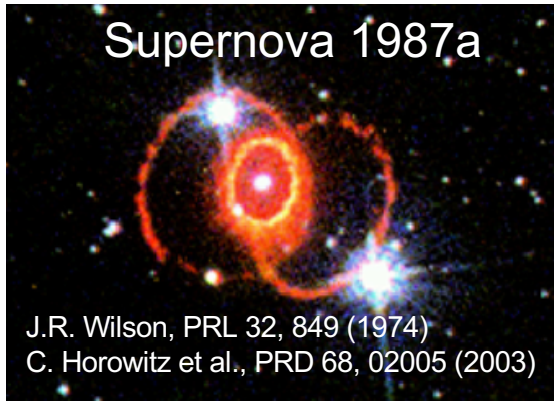
Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China and
School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

A.I. Studenikin^c

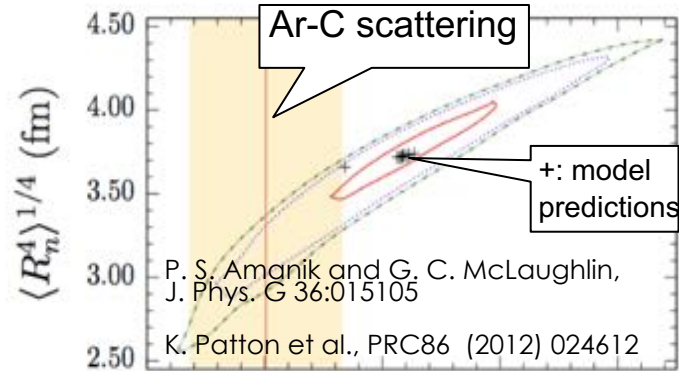
Department of Theoretical Physics, Faculty of Physics,
Lomonosov Moscow State University, Moscow 119891, Russia and
Joint Institute for Nuclear Research, Dubna 141980, Moscow Region, Russia
(Dated: March 15/16/18, 00:27)

Broad Impact of π -DAR CEvNS Studies

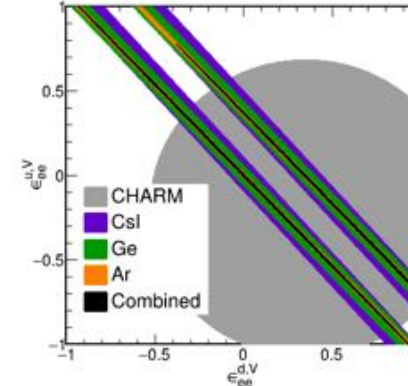
Largest σ in Supernovae dynamics



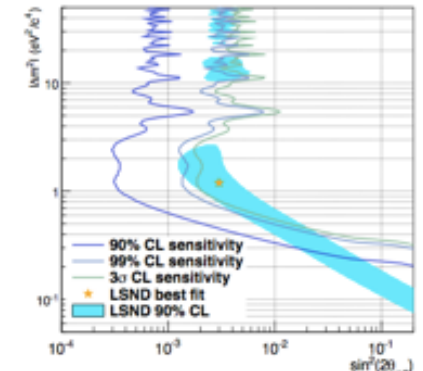
Nuclear Form Factors



Non-Standard Interactions

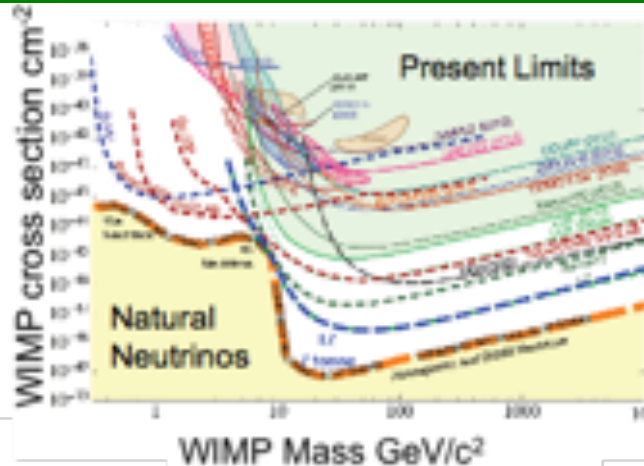


Sterile Searches

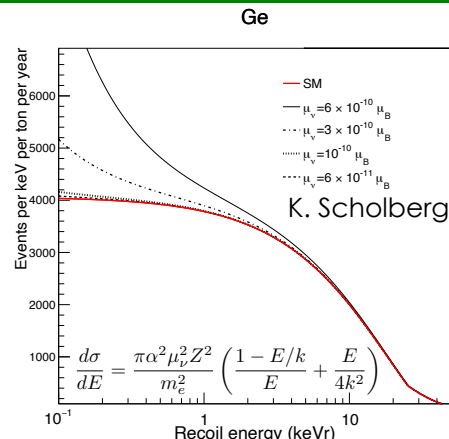


A. Anderson et al., PRD86 (2012) 013004

Background for Dark Matter searches

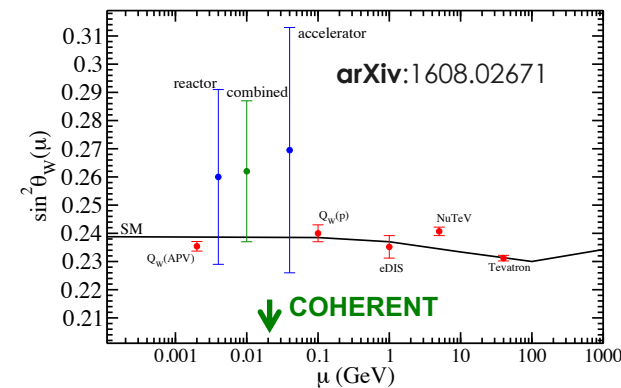


Neutrino Magnetic Moment

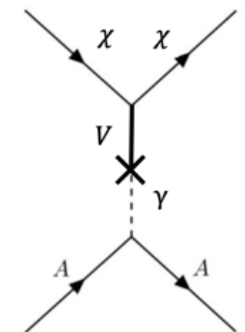


See also Kosmas et al., arXiv:1505.03202

Weak Mixing Angle

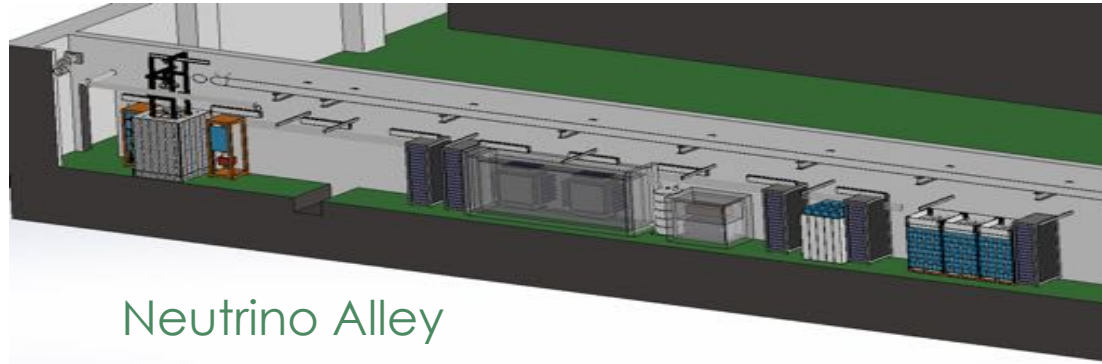


Accelerator DM searches



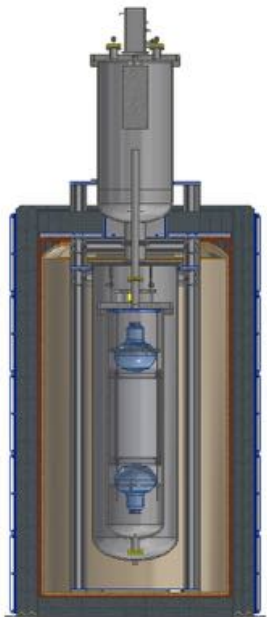
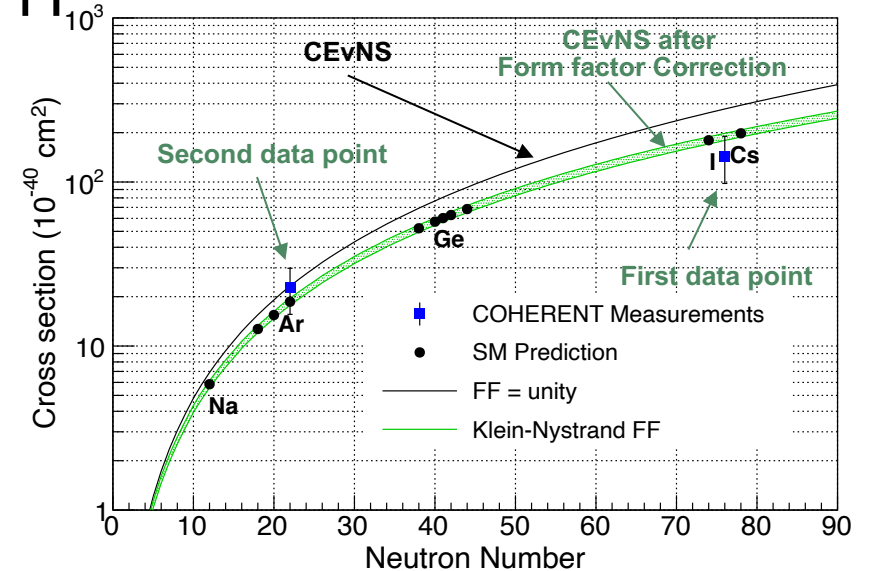
deNiverville et al.,
Phys Rev D92 095005 (2015)

COHERENT “First Light” CEvNS Program



Neutrino Alley

Complete the mapping of N^2 Dependence



Argon

- 24 kg Fiducial Mass
- Single Phase
- Kr^{83m} Calibrations
- 4.5 p.e. per keVee
- 20 keVnr threshold
- $\sim 5\sigma$ by Dec 2020

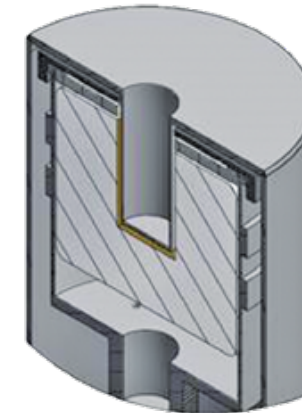
Poster #49
Jacob Zetlemoyer



Sodium (NaI)

- *Lightest-Nucleus*
- 3.4 ton NaI Array
- 3σ CEvNS/yr
- Installation 2020
- Funded DOE-ECA

Poster #554 Diane Markoff



Germanium

- *Lowest Threshold*
- 16 kg HPGe Array
- 500-600 CEvNS/yr
- Installation 2020
- Funded NSF-MRI

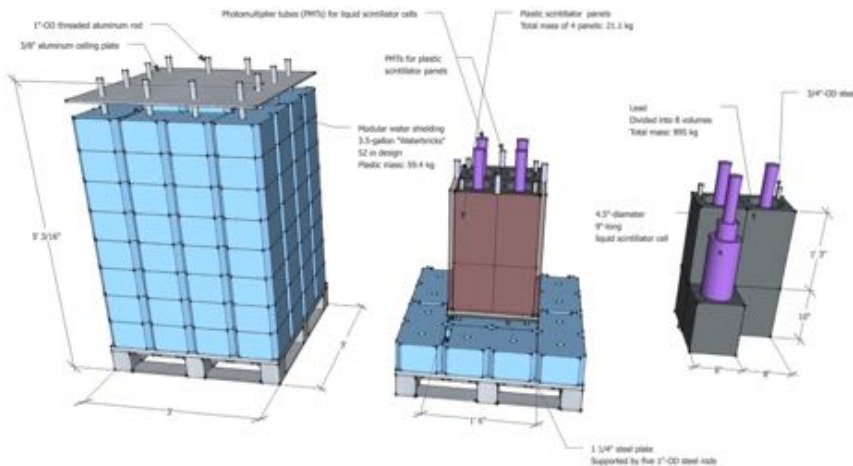
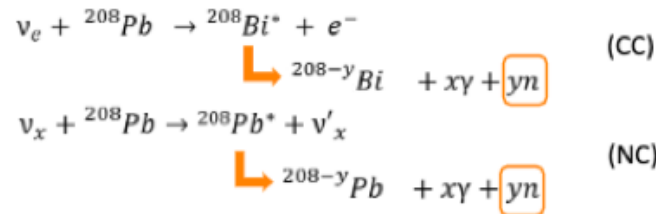
Posters:
#216 Long Li
#553 Keith Mann

Multiple Targets key feature of COHERENT

Neutrino 2020 Virtual Meeting

Inelastic Interactions and Physics Background Detectors Supporting the CEvNS Program

Neutrino Induced Neutron Detectors Pb & Fe Nubes

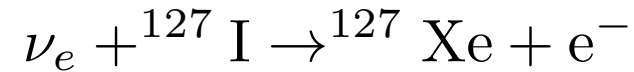


Designed by TUNL/Duke University
Installed in Neutrino Alley in 2014

Poster #428 Jacob Daughhetee

NalvE

Inelastic Interactions



Designed by TUNL/Duke University
Installed in Neutrino Alley

Posters:
#13 Peibo An
#420 Sam Hedges

Neutrino 2020 Virtual Meeting

MARS

Fast Neutron Backgrounds



Assembled at Sandia
Installed in Neutrino Alley in Jun 2017

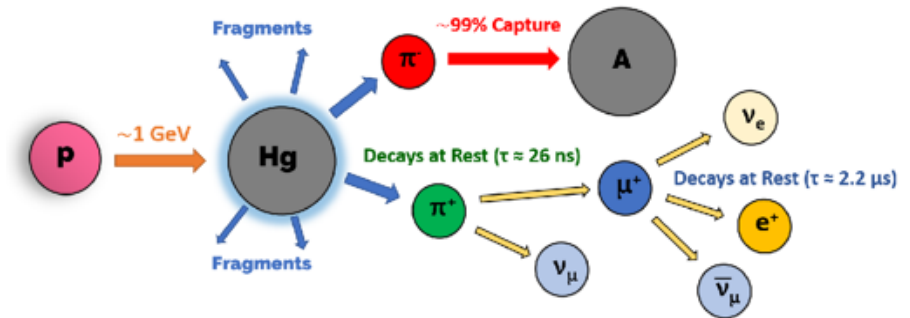
Poster #421 Rebecca Rapp

Beyond First Light Measurements ... CEvNS as quantitative probe

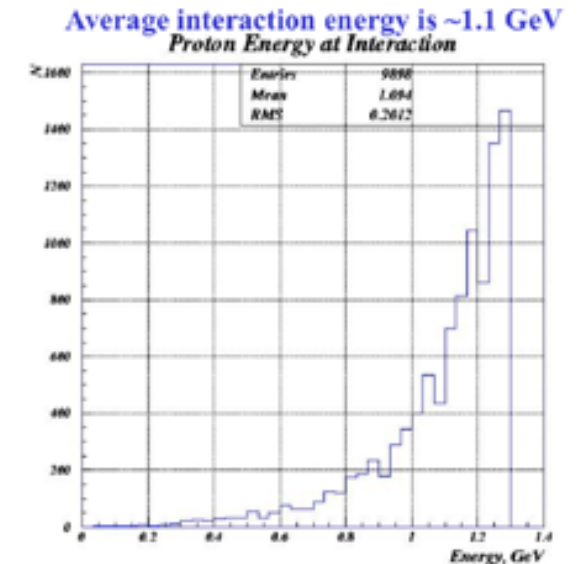
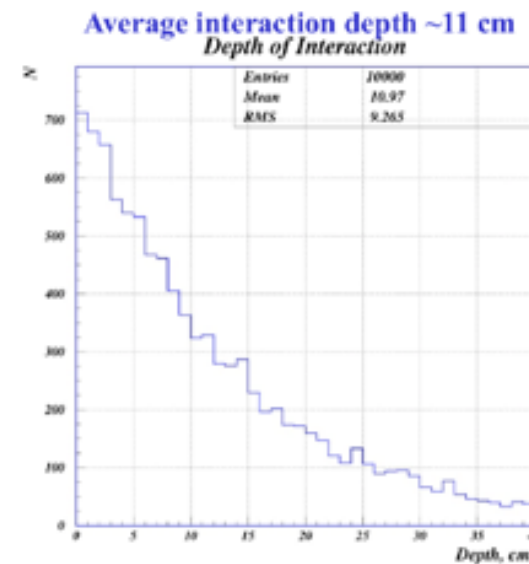
Dominant Uncertainties on Csl signal	
Event selection (signal acceptance)	5%
Form Factor	5%
Neutrino Flux	10%
Quenching factor	25%
Total uncertainty on signal	28%

Dominant Uncertainties on Ar CEvNS Rate	
Detector Model (includes QF)	2%
Fiducial Mass	2.5%
Prompt Light Fraction (Pulse Shape)	8%
Neutrino Flux	10%
Total uncertainty on signal	13.4%

All uncertainties except neutrino flux are detector specific and could be much less for other technologies



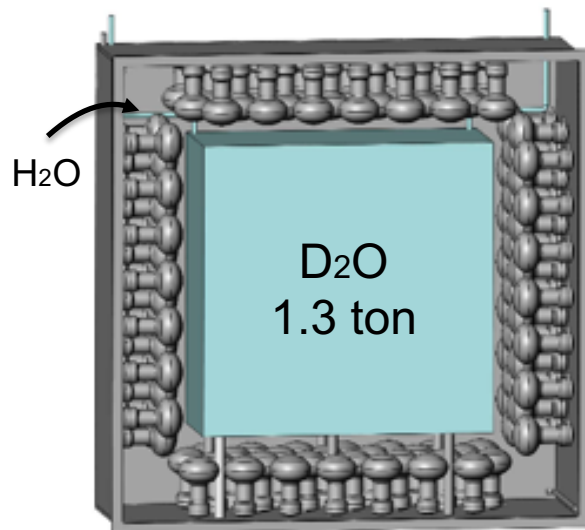
- Largest uncertainty is pion production from p+Hg
- 10% discrepancy between Bertini and LAHET calculations



To unlock high precision CEvNS program, we need to calibrate the SNS neutrino flux.

COHERENT Future Initiatives for a Precision Program

Precise Flux Normalization

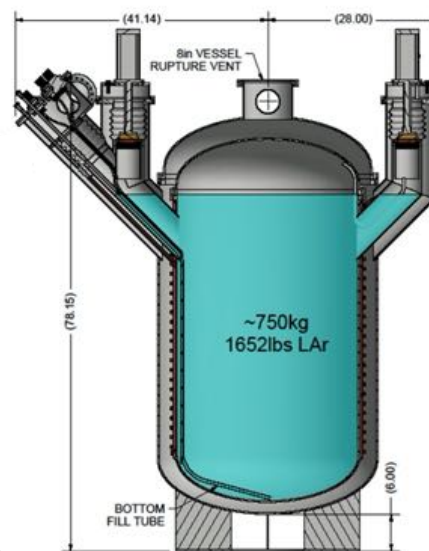


Darryl Dowling, ORNL
Concept: Yuri Efremenko

- Deuteron Charged Current
 $\nu_e + d \rightarrow p + p + e^-$
 - 2-3% Theoretical Uncertainty*
 - Calorimetry: no Ring Imaging
 - 2.5% Statistical in 2 yrs
- *S.Nakamura et. al. Nucl.Phys. A721(2003) 549

Poster #520
Karla R. Tellez-Giron-Flores

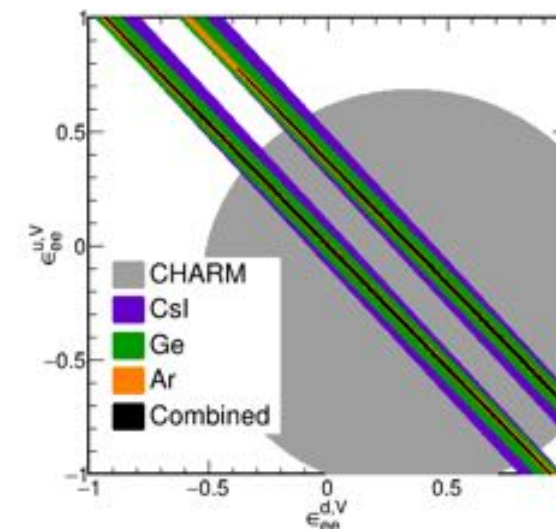
High Statistics CEvNS



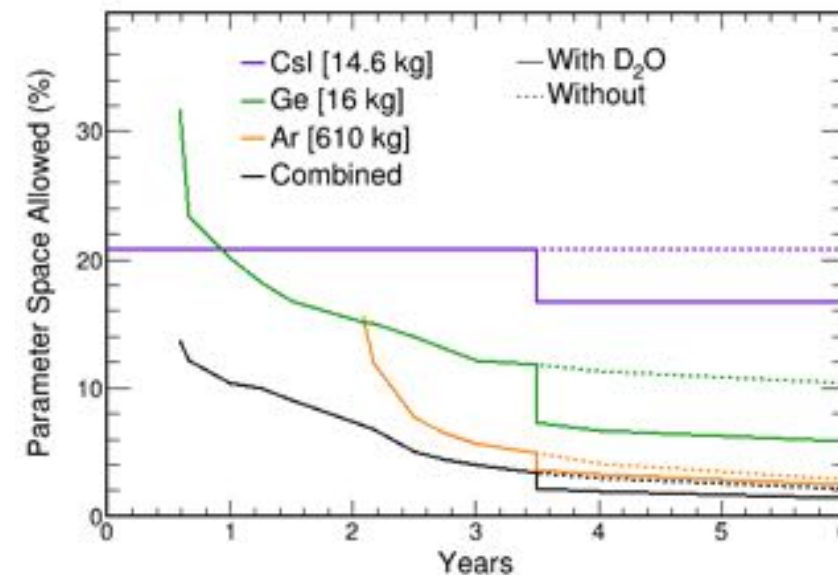
Walt Fox, IU

- 750kg LAr
- Single phase
- Light Collection Options
 - 3" PMT TPB
 - SiPM, Xenon Doping, ...
- ~3000 CEvNS/yr

Poster #501 Ben Suh



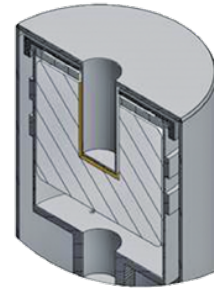
Significantly Improve NSI Constraints



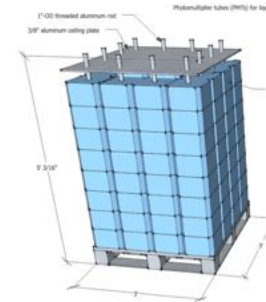
COHERENT Physics Overview



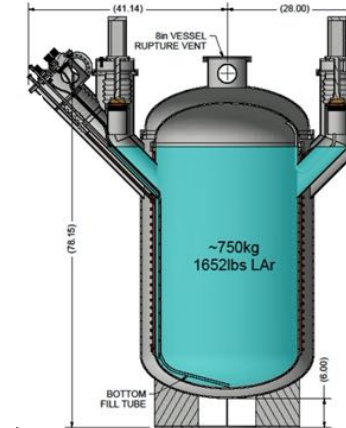
NaI



HPGe



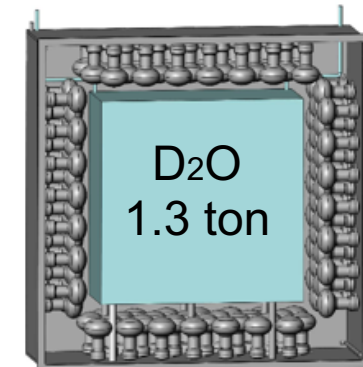
Nubes



Argon



CsI



Heavy Water

Non-standard neutrino interactions
Weak mixing angle
Accelerator-produced dark matter
Sterile oscillations
Neutrino magnetic moment
Nuclear form factors
Inelastic CC/NC cross sections for SN
Inelastic CC/NC cross sections for weak physics

Multiple Targets with complementary systematics best utilize neutrino source characteristics at the SNS

Future of Neutrinos at the SNS

Proton Power Upgrade

PPU project: Double the power of the existing accelerator structure

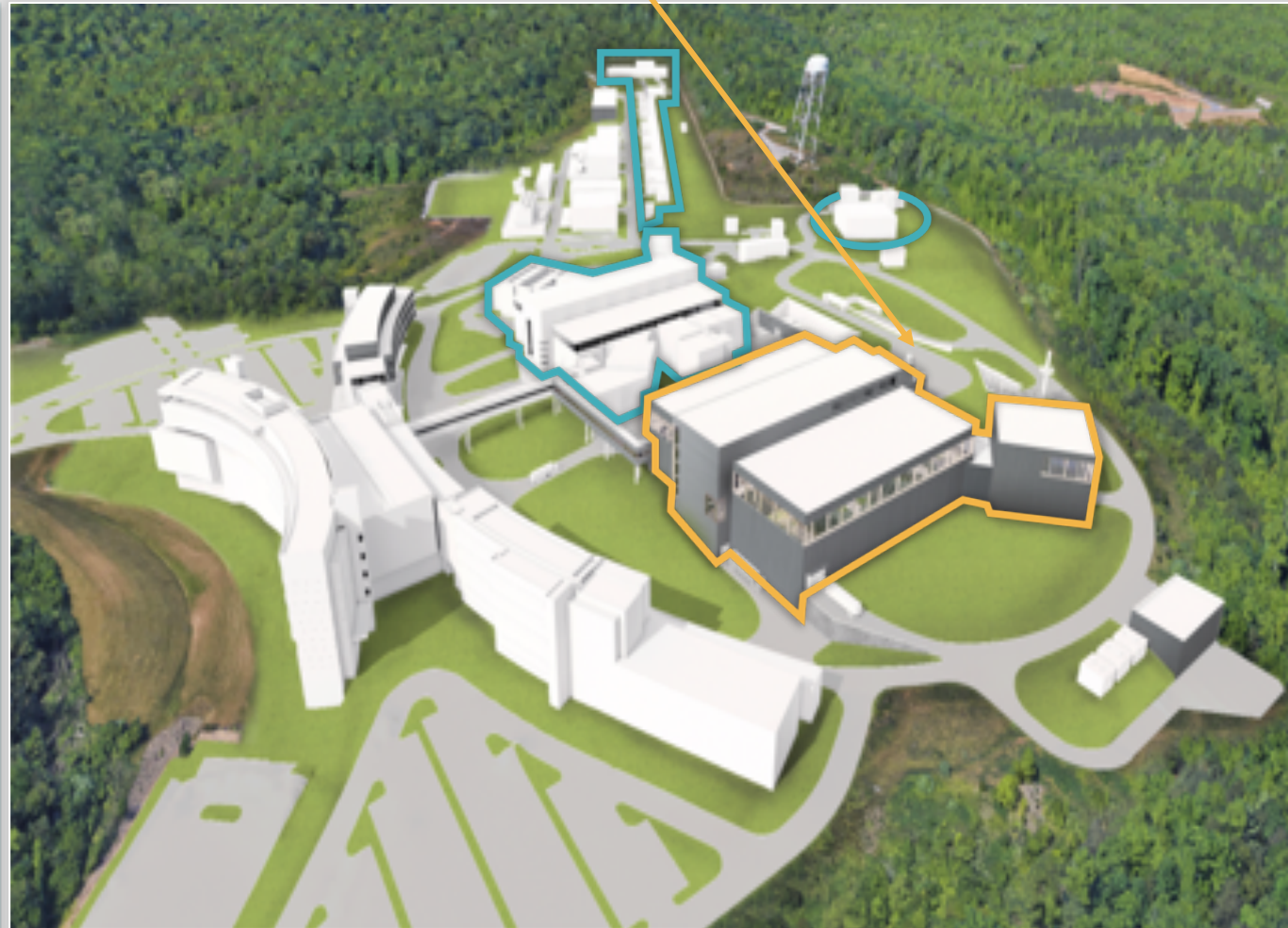
- First Target Station (FTS) is optimized for thermal neutrons
- Increases the brightness of beams of pulsed neutrons
- Provides new science capabilities for atomic resolution and fast dynamics
- Provides a platform for STS

Larger Neutrino Experimental Hall
Possible at STS: 2 10-ton Detectors

Second Target Station

STS project: Build the second target station with initial suite of beam lines

- Optimized for cold neutrons
- World-leading peak brightness
- Provides new science capabilities for measurements across broader ranges of temporal and length scales, real-time, and smaller samples



Slide from Ken Herwig, Workshop on Fundamental Physics at the Second Target Station (FPSTS18)

Power Upgrade and STS Facility create new opportunities ...

FTS	2021	2022	2024	2028	STS Neutrino Hall
1.4 MW		1.7 MW	2.0 MW		FTS: 2.0 MW @ 45 Hz STS: 0.7 MW @ 15 Hz

Calorimetry

COHERENT “First Light” Program

- CEvNS with HPGe, NaI
- Heavy Water Flux Normalization of FTS

Ton-Scale Argon Calorimetry

- CEvNS studies
- Dark Matter searches
- Limits on quark-lepton couplings for DUNE mass ordering degeneracy
- Low Threshold Detector R&D: Quantum Enhanced Light Collection, Xenon Doping, SiPM
- Supernovae neutrino cross sections for DUNE



We are just getting started!

Directionality

Ton-Scale Directionality with Low Threshold Detector R&D

Heavy Water Ring Imaging Design

- Improved Flux Normalization
- ν_e -oxygen Interactions for Super-K, Hyper-K

Argon Detector R&D for STS

- Scalable Low threshold Light Collection
- Advanced Techniques for Position/Direction Reconstruction
- Direction reconstruction for CC-leptons
- Multi-site reconstruction for coherent inelastic interactions

Discovery Scale

Neutrino Program at STS

10-ton Liquid Argon

- Dark Matter searches
- Precision CEvNS studies
- Precision Ar cross sections for DUNE
- Weak Mixing Angle
- Neutrino EM properties

Heavy Water Ring Imaging

- Flux Normalization of STS
- Precision ν_e -oxygen for Super-K, Hyper-K

Exact time evolution of program to be determined by the collaboration

New Constraints for NSI Quark-Lepton Couplings

“Dark side” solution remains viable

O. G. Miranda, M. A. Tortola and J. W. F. Valle, Are solar neutrino oscillations robust?, JHEP 10 (2006) 008, [hep-ph/0406280].

$$\mathcal{L}_{\text{NSI}} = -2\sqrt{2}G_F\epsilon_{\alpha\beta}^{f,V}(\bar{\nu}_{\alpha L}\gamma^\mu\nu_{\beta L})(\bar{f}\gamma_\mu f),$$

Coloma, Gonzalez-Garcia, Maltoni, Schwetz
arXiv:1708.02899

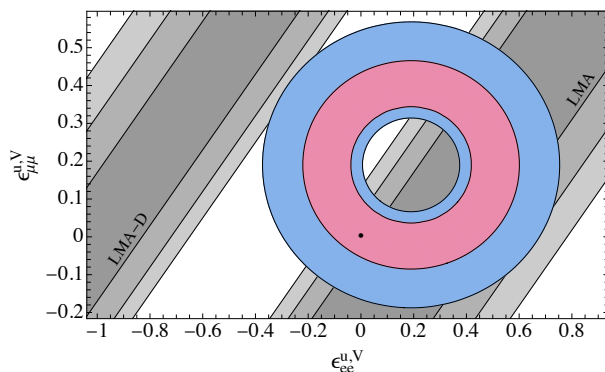
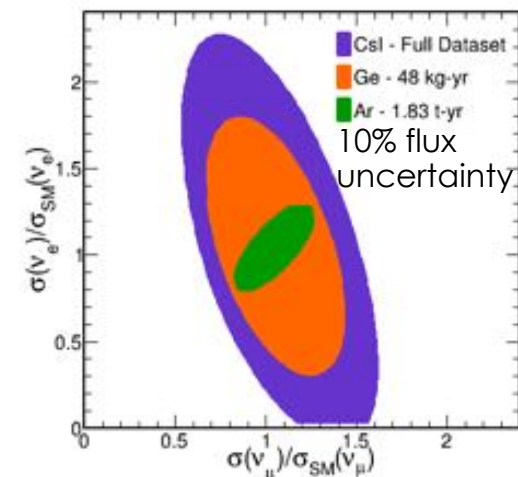
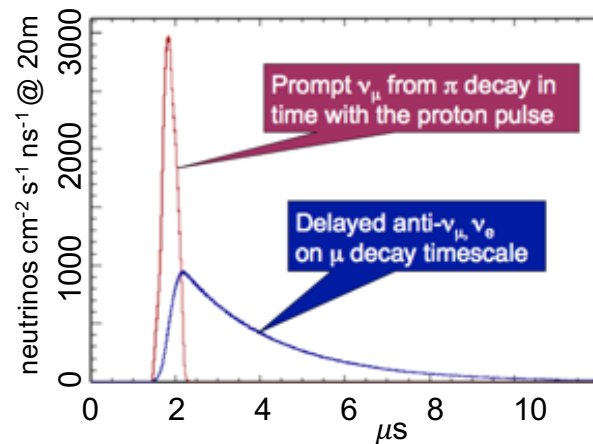


FIG. 2: Allowed regions in the plane of $\epsilon_{ee}^{u,V}$ and $\epsilon_{\mu\mu}^{u,V}$ from the COHERENT experiment shown together with the allowed regions from the global oscillation analysis. Diagonal shaded bands correspond to the LMA and LMA-D regions as indicated, at 1σ , 2σ , 3σ (2 dof). The COHERENT regions are shown at 1σ and 2σ only because the 3σ region extends beyond the boundaries of the figure.

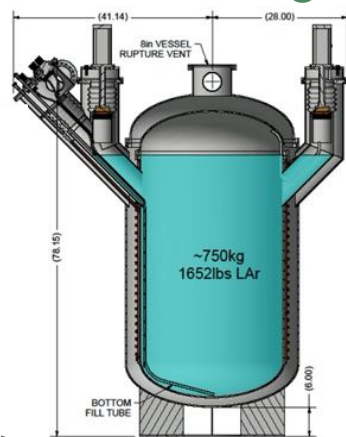
CEvNS measurements can resolve NSI-related ambiguity in DUNE mass ordering determination

Time-Resolved Flavor Structure

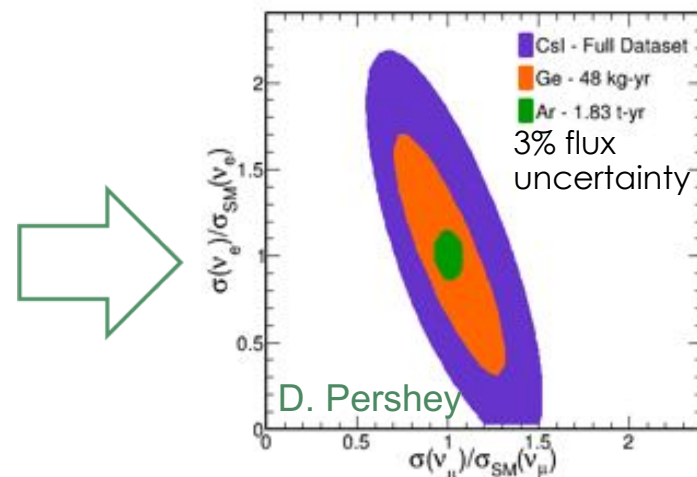
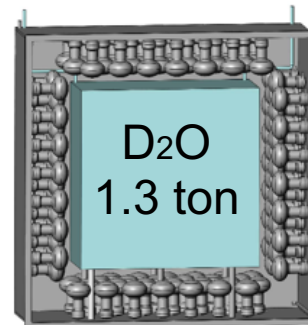


Future measurements with HPGe and precision measurements with ton-scale Argon will combine advantages of **energy resolution (HPGE)** and simultaneous measurements of **time-resolved muon and electron flavors (LAR)**.

Ton-Scale Argon

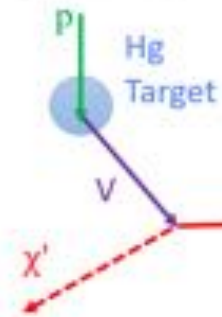


Precision Flux Calibration



Accelerator-produced Dark Matter at the SNS

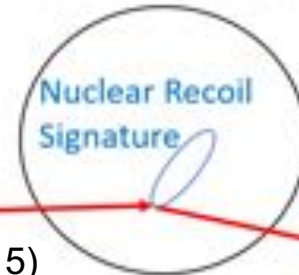
SNS proton beam



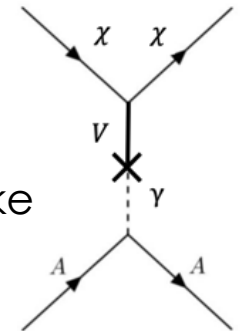
Portal particles would be produced mainly through $\pi^0/\eta^0 \rightarrow V\gamma$.

deNiverville et al., Phys Rev **D92** 095005 (2015)

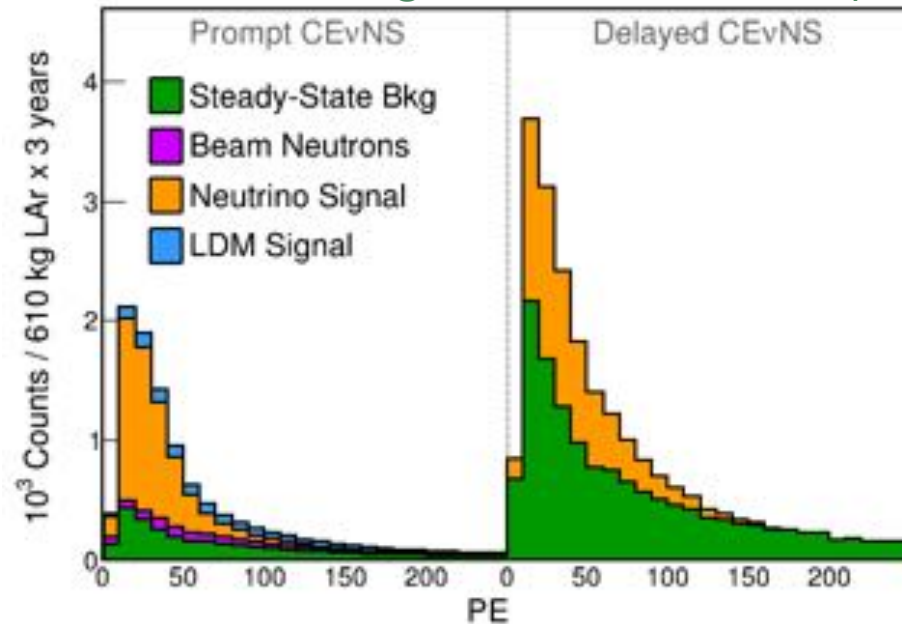
COHERENT detector



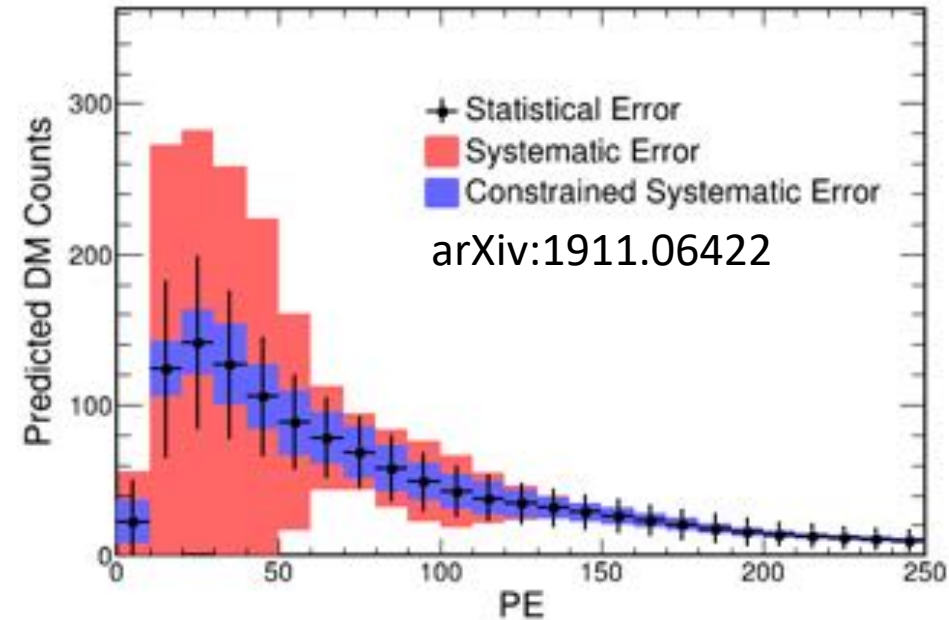
These hidden sector particles would interact within our detectors in Neutrino Alley in CEvNS-like recoils.



Ton-scale Argon in Neutrino Alley



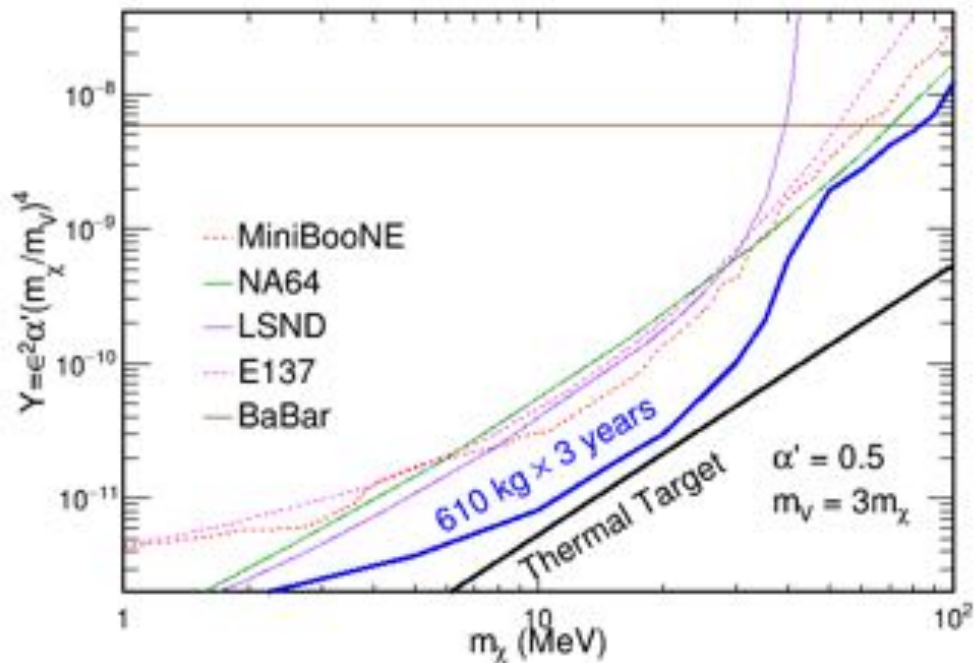
See D. Pershey's talk from [M7s](#)



The ability to measure delayed CEvNS key to control systematics of prompt CEvNS “background”.

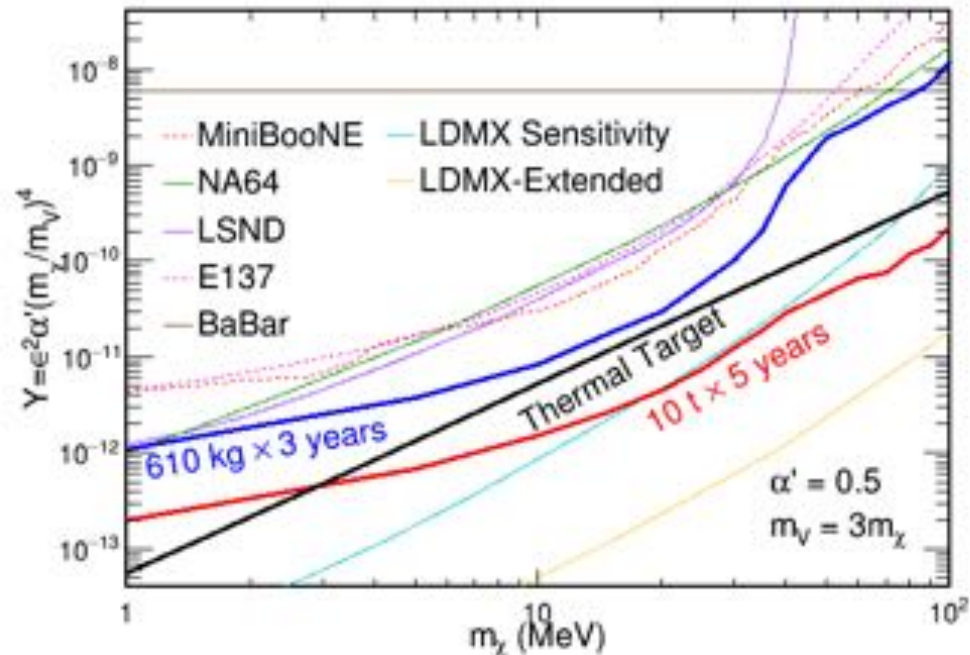
Accelerator-produced Dark Matter at the SNS

SNS First Target Station



See D. Pershey's talk from [M7s](#)
arXiv:1911.06422

SNS Second Target Station



Scalar DM excluded
for all $\alpha' < 1$ for $5 < m_\chi < 100$ MeV

Probing thermal target region within 5-years with 10-ton mass at STS.

Summary

- The Spallation Neutron Source is currently the purest, most intense stopped pion neutrino source with stable operation planned for decades.
- COHERENT has demonstrated the ability to measure CEvNS on wide range of targets at the SNS.
- Multiple targets (Ar, Ge, Na, Cs, I, D) deployed (or planned) by the COHERENT collaboration in neutrino alley have created a rich neutrino physics program with broad scientific impact.
- Power Upgrades and Second Target Station Operations at the SNS provide new opportunities for precision neutrino measurements and DM searches.



Acknowledgements

We are grateful for logistical support and advice from SNS (a DOE Office of Science facility). Much of the background measurement work was done using ORNL SEED funds, as well as Sandia Laboratories Directed Research and Development (LDRD) and NA-22 support. LAr detector deployment is supported by ORNL LDRD funds and the CENNS-10 detector is on loan from Fermilab. We thank Pacific Northwest National Laboratory colleagues and Triangle Universities Nuclear Laboratory for making resources for various detector components available. COHERENT collaborators are supported by the U.S. Department of Energy Office of Science, the National Science Foundation, NASA, and the Sloan Foundation.

COHERENT Post-docs and Students



Rebecca Rapp
CMU
CB Rep.



Sam Hedges
Duke



Long Li
DUKE



Alexander Kumpan
MEPhI



Connor Awe
Duke



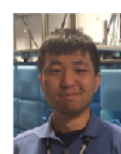
Justin Raybern
Duke



Brandon Becker
UTK



Hector Moreno
UNM



Ben Suh
IU



Jes Koros
Duke



Alexey Konovalov
MEPhI



Karla Tellez-Giron-Flores
VT



Erin Conley
Duke



Igor Bernardi
UTK



Dan Pershey
Duke
(Postdoc)



Jacob Daughhetee
UTK (Postdoc)



Max Hughes
IU
(Postdoc)

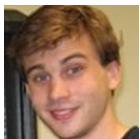
Undergraduates and Summer Students

Katrina Miller, Duke

Lara Blokland, UTK

Abasi Brown, NCCU

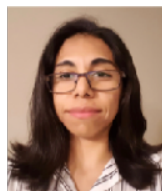
Former COHERENT postdocs



John Sparger
ORNL



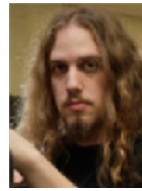
Ivan Tolstukhin
IU



Mayra Cervantes
Duke



Josh Albert
IU



Dan Salvat
UW

7 PhD dissertations completed 2 Dissertation awards



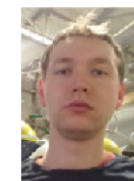
Bjorn Scholz
U of Chicago
Tanaka Award 2020



Grayson Rich
TUNL-UNC
APS-DNP Award 2018



Matthew Heath
Indiana University



Alex Khromov
MEPhI



Gleb Sinev
Duke



Dmitry Rudik
MEPhI



Jacob Zettlemoyer
Indiana University

Posters

- NalvE and NaI:
 - #13 – A Machine Learning Approach to Study $^{127}\text{I}(\nu_e, e)^{127}\text{Xe}$ (Peibo An)
 - #420 - Electron Neutrino Charged-Current Interactions on I-127 in the COHERENT NalvE Detector (Sam Hedges)
 - #554 - A Ton-Scale NaI Detector for Neutrino-Nucleus Scattering Measurements (Diane Markoff)
- Neutrino-induced Neutrons:
 - #428 - Neutrino-Induced Neutron Detectors at the Spallation Neutron Source (Jacob Daughhetee)
- Liquid Argon:
 - #49 - First Detection of CEvNS on Argon with the CENNS-10 Liquid Argon Detector (Jacob Zettemoyer)
 - #501 - CENNS-750: A Ton-Scale Liquid Argon Detector for CEvNS at the SNS (Ben Suh)
- Neutrino Flux Normalization with D_2O :
 - #520 - A Flux Normalization Detector for the COHERENT Experiment (Karla R. Tellez-Giron-Flores)
- MARS:
 - #421 - Studying neutron backgrounds for COHERENT with MARS (Rebecca Rapp)
- Ge:
 - #216 - Quenching Factor Measurements for Germanium Detectors at TUNL (Long Li)
 - #553 - Measuring CEvNS with Ge (Keith Mann)

Thank you.

Questions?

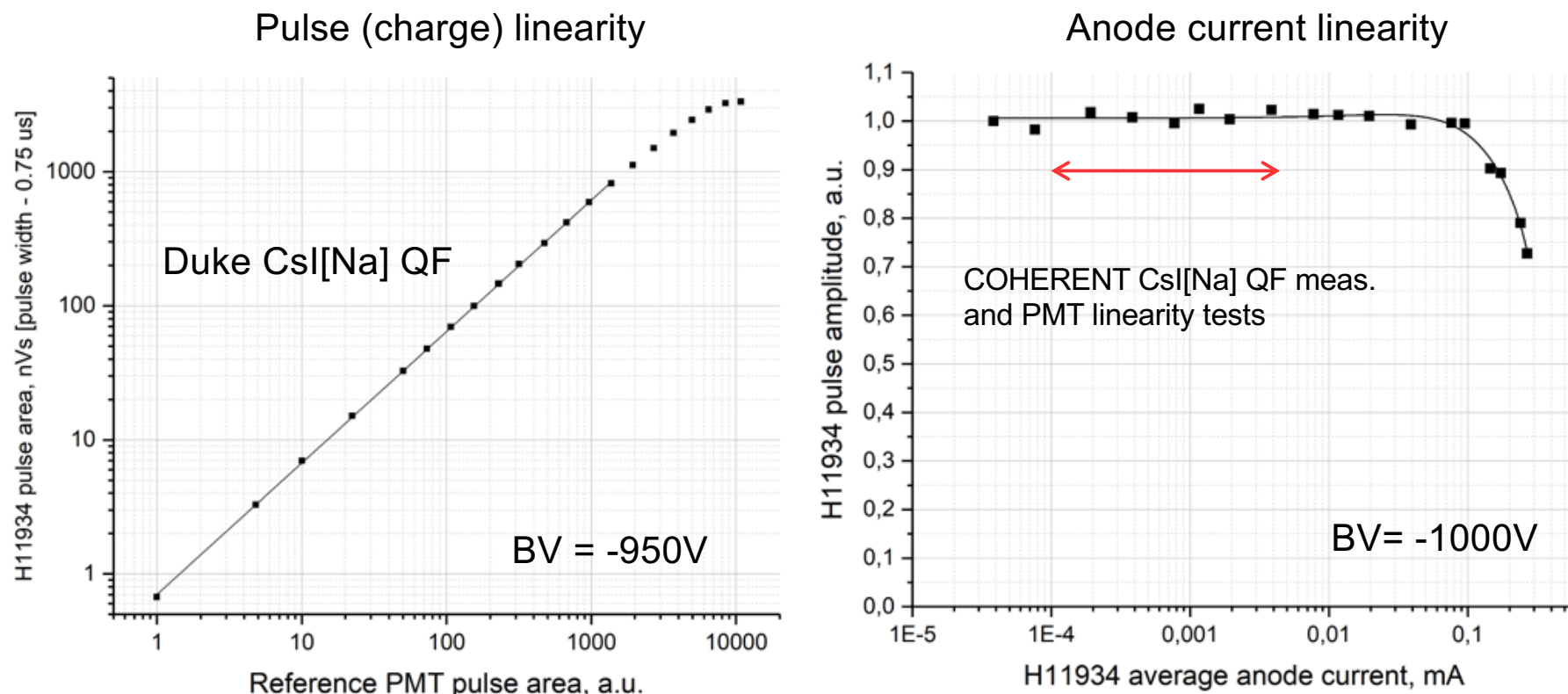


Auxiliary Slides



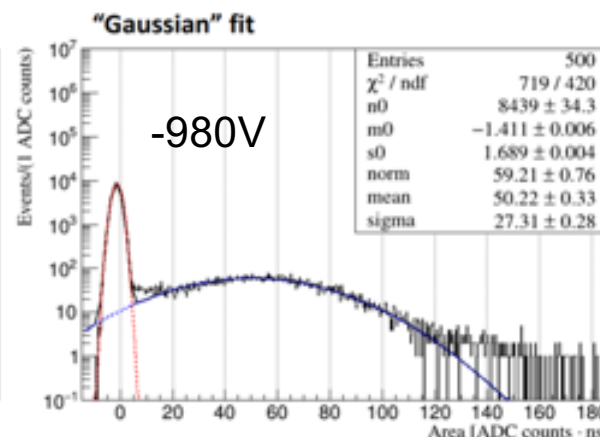
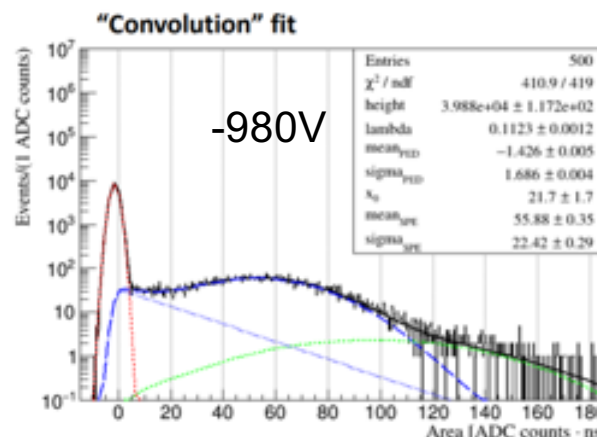
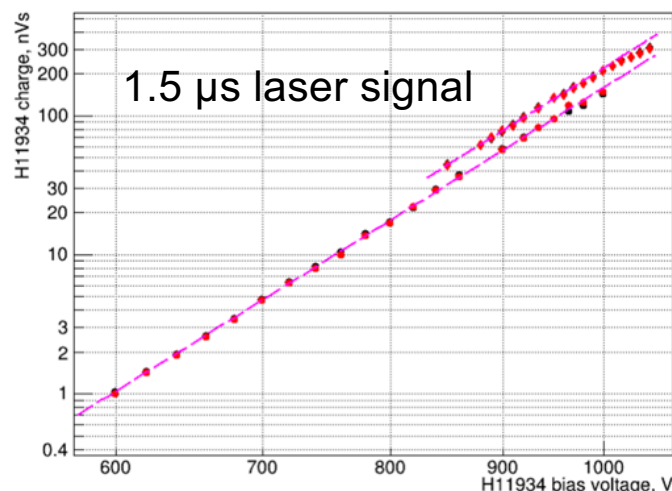
Linearity tests of H11934-200 PMT used for CsI[Na] measurements

LED/laser light pulses were tuned to be both larger in amplitude and faster than CsI[Na] signals of the same charge. Stability of the light sources was monitored with a reference PMT (FEU-143).

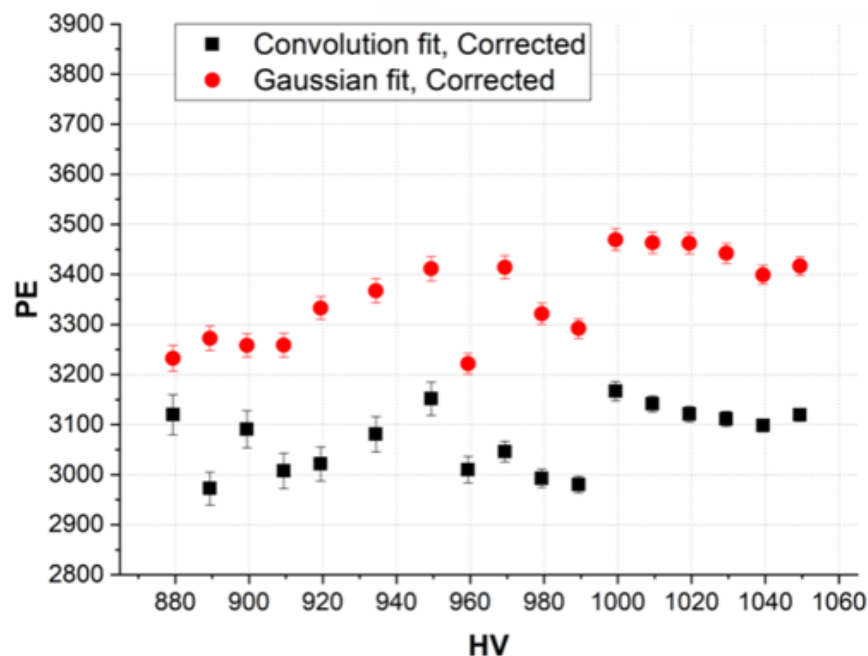


The scale of non-linearity effects appearance coincide with ones from the manufacturer's info

Linearity tests of H11934-200 PMT used for CsI[Na] measurements



Gaussian-based model doesn't describe the «valley» well



For signals larger and faster than 59.5 keV CsI[Na] response no significant change of the size of the signal in PE with the change of PMT bias voltage

Two-pulse method also verifies linearity of the PMT on the scale of CsI[Na] response to 59.5 keV

* — correction based on the reference PMT to take into account laser intensity fluctuations

** — only fit stat. errors included

Neutrino 2020 Virtual Meeting

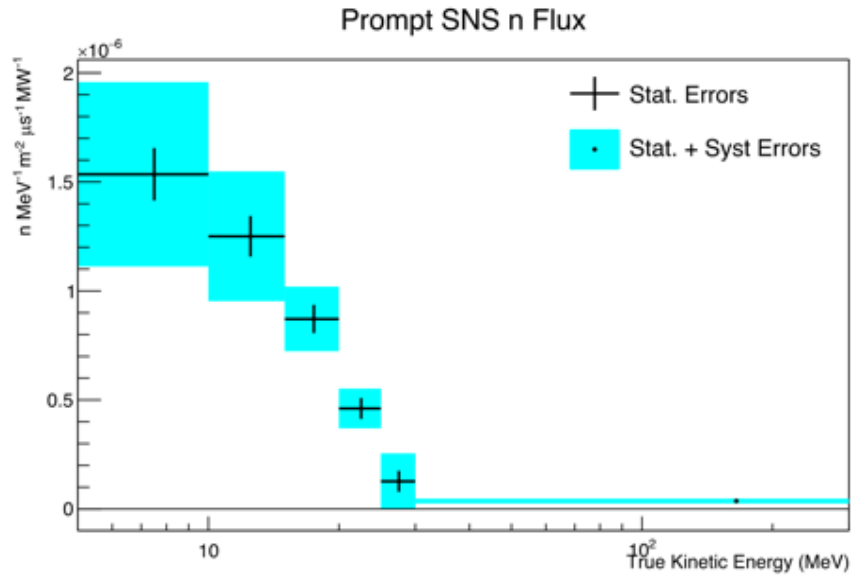
COHERENT Physics Overview

Topic	CsI	Ar	NaI	Ge	Nubes	D ₂ O
Non-standard neutrino interactions	✓	✓	✓	✓		
Weak mixing angle	✓	✓	✓	✓		
Accelerator-produced dark matter	✓	✓	✓	✓		
Sterile oscillations	✓	✓	✓	✓		
Neutrino magnetic moment		✓	✓	✓		
Nuclear form factors	✓	✓	✓	✓		
Inelastic CC/NC cross-section for supernova		✓			✓	✓
Inelastic CC/NC cross-section for weak physics		✓	✓		✓	✓

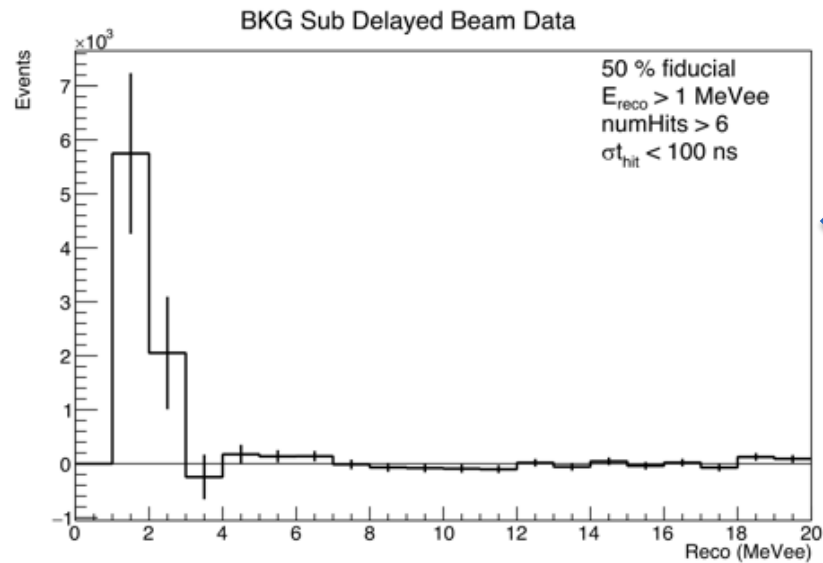
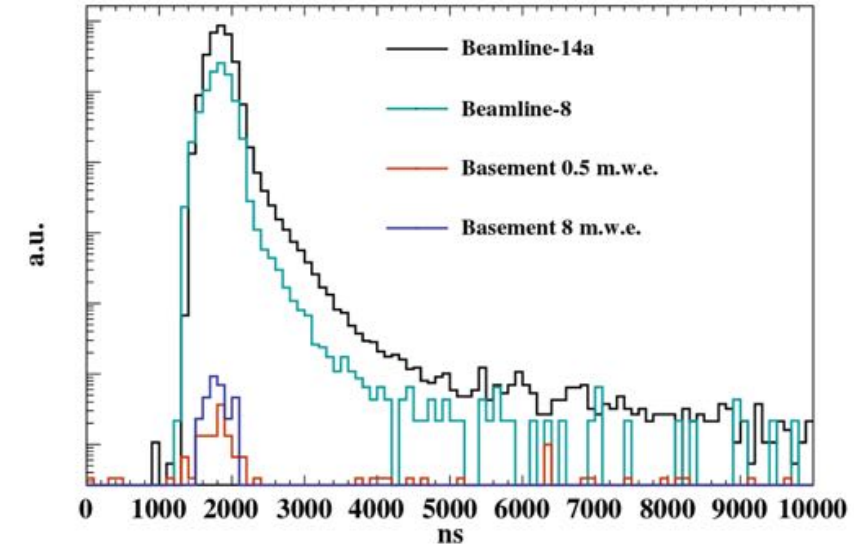
 The sum is greater than the individual measurements

 All measurements benefit from neutrino flux normalization

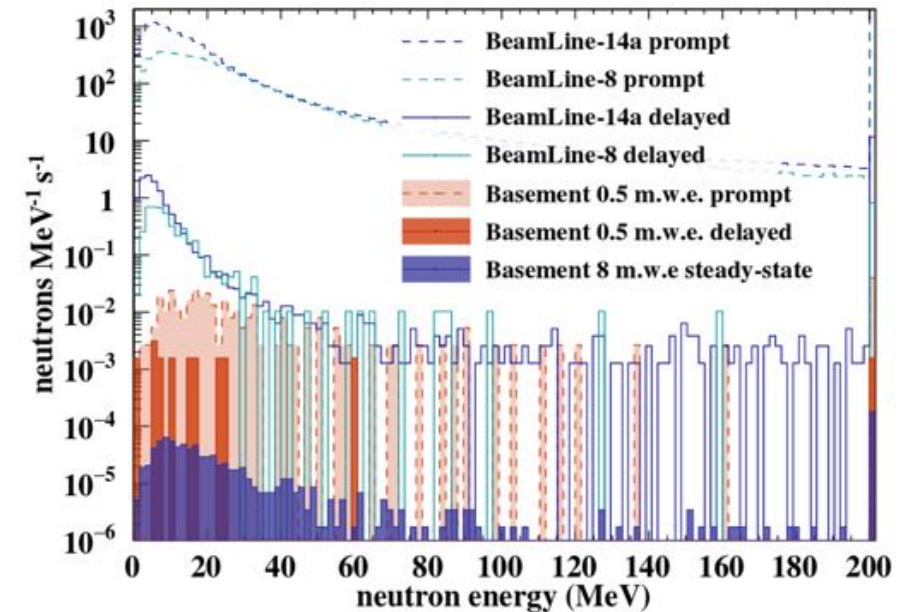
Neutron Flux Measurements in the basement



Sandia Scatter Camera



IU SciBath

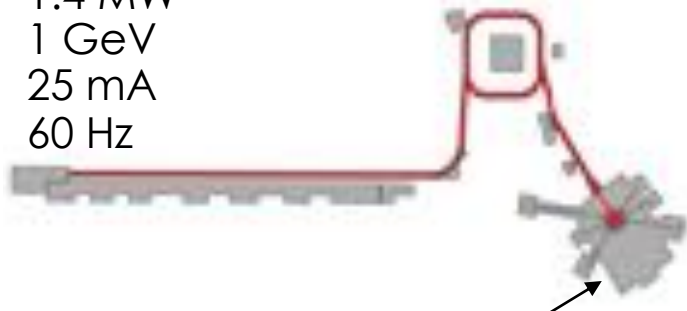


PPU and STS upgrades will ensure SNS remains the world's brightest accelerator-based neutron source

Today

- 900 users
- Materials at atomic resolution and fast dynamics

1.4 MW
1 GeV
25 mA
60 Hz



FTS
1.4 MW
60 Hz

2024 after PPU

- **1000+** users
- Enhanced capabilities

2.0 MW
1.3 GeV
27 mA
60 Hz

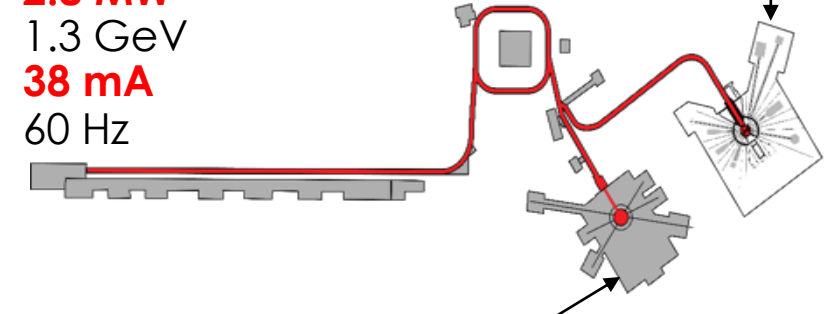


FTS
2 MW
60 Hz

2028 after STS

- **2000+** users
- Hierarchical materials, time-resolution and small samples

2.8 MW
1.3 GeV
38 mA
60 Hz



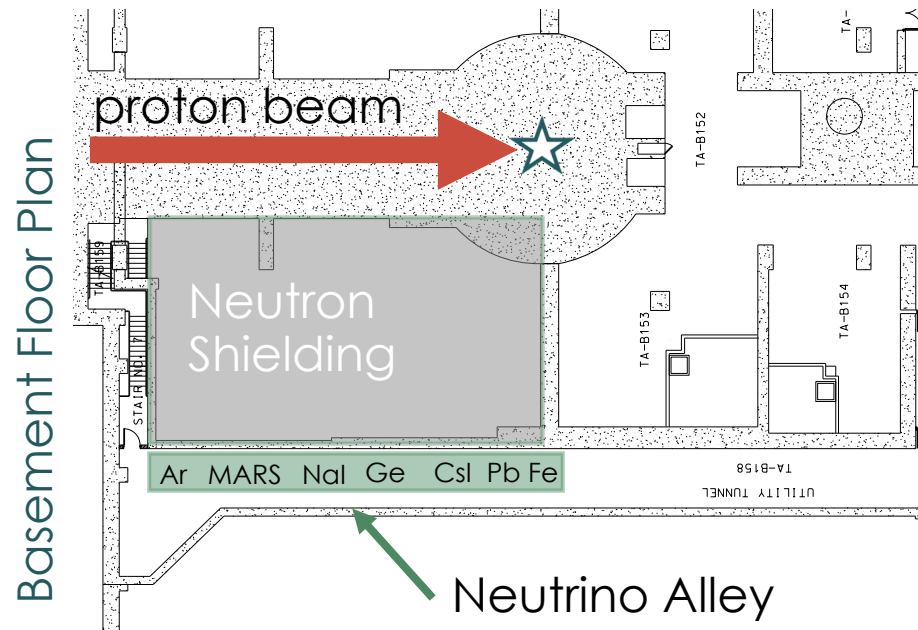
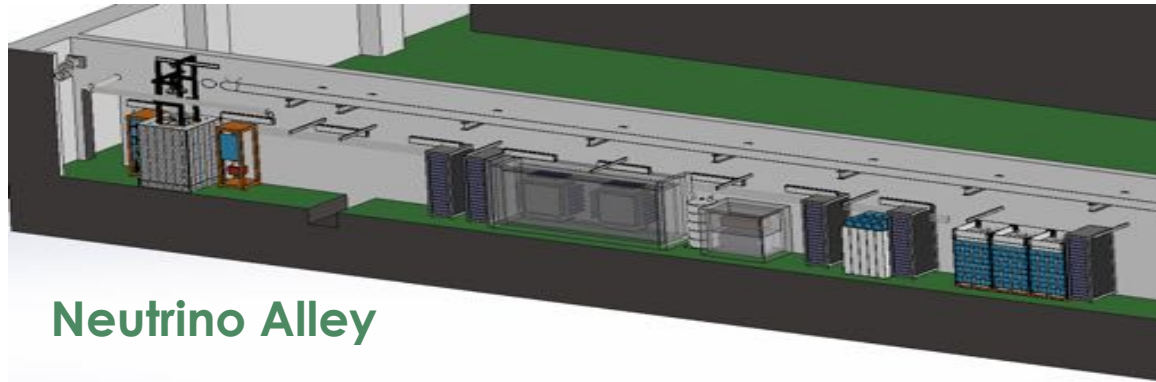
STS
0.7 MW
15 Hz

FTS
2 MW
45 pulses/sec

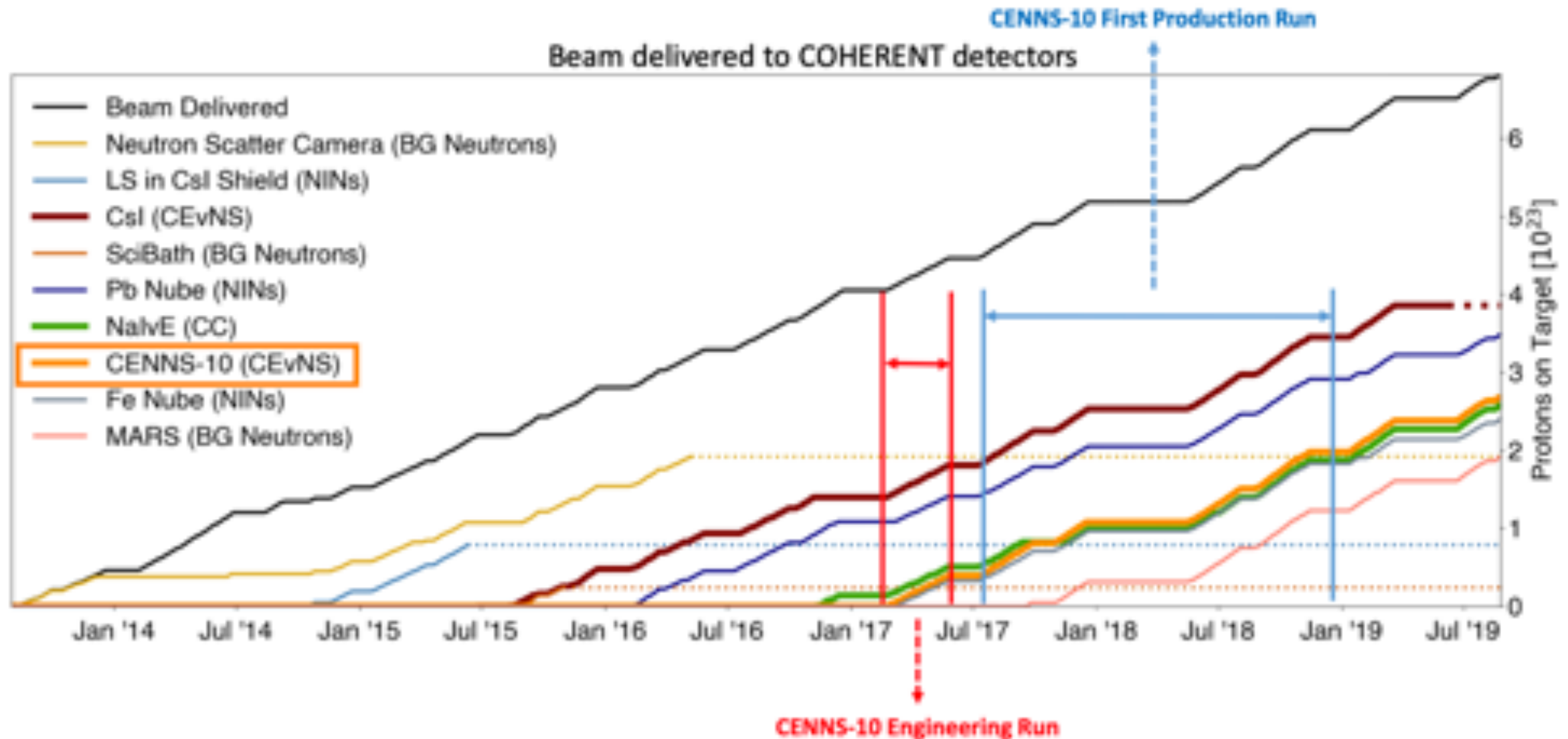
The choice of 15 Hz and 0.7 MW resulted from a detailed analysis of STS design (reviewed by a panel of experts in 2017) and optimizes performance of STS without impacting performance of FTS



Neutrino Alley



SNS Neutrino Production



π -DAR Sources

